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Association of Cervical Effacement With the Rate of Cervical Change in Labor Among Nulliparous Women

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Abstract

Objective—To assess the association of cervical effacement with the rate of intrapartum cervical change among nulliparous women.

Methods—We conducted a secondary analysis of a prospective trial of intrapartum fetal pulse oximetry. For women who had vaginal deliveries, interval censored regression was used to estimate the time to dilate at one centimeter intervals. For each given centimeter of progressive cervical dilation, women were divided into those who had achieved 100% cervical effacement and those who had not. The analysis was performed separately for women in spontaneous labor and those who were given oxytocin.

Results—Three thousand nine hundred two women were included in this analysis, 1,466 (38%) who underwent labor induction, 1,948 (50%) who underwent labor augmentation (combined for the analysis), as well as 488 (13%) who labored spontaneously. For women in spontaneous labor, the time to dilate 1 cm was shorter for those who were 100% effaced starting at 4 cm of cervical

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dilation (P = 0.01 to P < 0.001). For women who received oxytocin, the time to dilate 1 cm was shorter for those who were 100% effaced throughout labor (P < 0.001).

Conclusion—The rate of cervical dilation among nulliparous women is associated with not only the degree of cervical dilation, but also with cervical effacement.

Clinical Trial Registration—ClinicalTrials.gov, www.clinicaltrials.gov, NCT00098709.

Précis

Achievement of 100% cervical effacement is associated with a shorter median time of dilation among nulliparous women.

Introduction

In recent years, the Consortium on Safe Labor (CSL) labor curves have replaced the traditional labor curve proposed by Friedman (1–3, 4). The importance of understanding normal labor progression was highlighted by Rouse and colleagues in 1999 when they challenged the idea that arrest of labor could be diagnosed after only 2 hours of inadequate cervical change (5). Rouse and colleagues found that 60% of women who were given 2 additional hours to demonstrate cervical change went on to deliver vaginally. This observation highlighted that an inappropriate model of normal labor can lead to an over diagnosis of arrest disorders of labor and subsequently unnecessary cesarean deliveries. The American College of Obstetrics and Gynecology and the Society for Maternal-Fetal Medicine consensus statement on the Safe Prevention of the Primary Cesarean Delivery recommends using the CSL labor curves to define normal labor progress (6).

The CSL labor curve emphasizes the notion that active labor may not begin until 6 cm of cervical dilation. The CSL labor curve does not specifically address the role of cervical effacement in predicting normal rates of cervical change. Cervical effacement, however, has been used by many authors as a traditional part of the definition of active labor (7) and clinical experience would suggest that cervical effacement plays a role in labor progress. The current study assesses the association of cervical effacement with the rate of intrapartum cervical change among nulliparous women.

Materials and Methods

We conducted a secondary analysis of a prospective trial of fetal pulse oximetry conducted by the National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network (8). In the original study, women were eligible to participate if they were nulliparous with a singleton, cephalic, living fetus at or beyond 36 weeks of gestation. Exclusion criteria included a planned cesarean delivery, maternal temperature ≥38°C, maternal HIV or hepatitis infection, maternal heart or renal disease and diabetes mellitus requiring insulin. Women were enrolled with cervical dilations between 2 and 6 cm. Labor was managed according to the usual clinical practice at the participating centers. The original study was approved by the institutional review board at each participating Maternal-Fetal Medicine Units Network center and written informed consent was obtained from each participant. Data were collected by trained research nurses.

For the current study, we included all participants who had a vaginal delivery of a live-born infant. There were no stillbirths. A separate analysis included those participants who had a cesarean delivery for an arrest disorder. We abstracted data on patient race, body mass index, use of epidural anesthesia, use of oxytocin for labor induction or augmentation, use of cervical ripening agents, and details of labor progression including cervical dilation and effacement at each exam.

When comparing demographic and other patient characteristics between those with induced or augmented labor to those with spontaneous labor, the Wilcoxon rank-sum test was used to compare continuous variables, and categorical variables were compared by means of the chi-square or Fisher's exact test, as appropriate. Analyses are presented separately for those with induced or augmented labor and those with spontaneous labor. Cervical effacement was recorded as a percentage of effacement (0–100%). Given that measurements of cervical effacement can often vary significantly by observer (9, 10) as well as the presumed clinical importance of achieving 100% cervical effacement, women were stratified into those who had achieved 100% cervical effacement and those who had not at each cervical exam. We used interval-censored regression to estimate the time to progress from one integer centimeter dilation to the next, assuming a log-normal distribution (11). Since cervical exams are often irregularly spaced, an individual may have progressed several centimeters of dilation from one exam to the next. Therefore, interval-censoring allows an estimation of the time between any two one-centimeter measurements (e.g., from 4 cm to 5 cm), even when those precise measurements were not observed for all patients. The median, 5^{th} percentile, and 95^{th} percentile were calculated for the time to progress between every two successive dilations, and the times for those at 100% effacement versus less than 100% effacement were compared with a Wald test using procedure LIFEREG in SAS Version 9.3. Using these same methods, a model was constructed with the covariates of 100% cervical effacement (yes vs. no), use of regional anesthesia (yes vs. no), maternal BMI, age, and race (white vs. all others). To calculate the cumulative time from 4 cm, 5 cm, and 6 cm to complete cervical dilation, right-censored regression assuming a log-normal distribution was used, with effacement assessed at the initial cervical dilation. Among women whose labor was induced, a model was constructed with additional terms for mechanical ripening, medical ripening, and their interactions with 100% cervical effacement. Finally, these analyses were repeated for the women who had cesarean deliveries for arrest disorders.

Results

The original trial randomized 5,341 women. Of these, 1,439 women had a cesarean delivery, leaving 3,902 women with vaginal deliveries in this analysis. There were no stillbirths. The current cohort included 1,466 (38%) women who underwent labor induction and 1,948 (50%) who underwent labor augmentation with oxytocin (combined for the analysis), as well as 488 (13%) women who labored spontaneously. Women in spontaneous labor were different from those women who were augmented or induced in most baseline characteristics, though the absolute magnitude of the differences was small (Table 1). Missing information on cervical effacement was rare. Fewer than 1% of cervical examinations were missing an effacement measurement.

For women who received oxytocin during labor, the time to dilate from each centimeter to the next was significantly shorter for women who were 100% effaced compared with those who were not (Table 2). For women who had spontaneous labor, the time to dilate from 2 to 3 cm and 3 to 4 cm did not differ by effacement, while the time to dilate from 4 to 5 cm, 5 to 6 cm, 6 to 7 cm, 7 to 8 cm, 8 to 9 cm and 9 to 10 cm was significantly shorter for those who were 100% effaced vs. those who were not (Table 2). When potential confounders including maternal race, age, BMI at the time of delivery, and use of regional anesthesia were considered in the model, the trend remained unchanged (Table 3).

For women who received oxytocin during labor, the time to reach 10 cm of cervical dilation from 4, 5, and 6 cm respectively was longer for those women who had not yet achieved 100% cervical effacement at the starting dilation. For women in spontaneous labor, this was true for 4 and 5 cm of cervical dilation. However, the 100% cervical effacement at 6 cm dilation was not associated with a significantly shorter duration to reach 10 cm dilation (Table 4).

Among women whose labors were induced, 370 (25.2%) were medically ripened and 243 (16.6%) were mechanically ripened. Medical ripening shortened the time to dilate from 6 to 7 cm beyond the effect of 100% effacement (p=0.03), but not at other dilations. Mechanical ripening shortened the time to dilate from 9 to 10 cm beyond the effect of 100% effacement (p=0.01), but not at other dilations.

From the 1,439 women who had a cesarean delivery, we performed an analysis of the 985 who delivered by cesarean for an arrest disorder in the first (n=773) or second (n=212) stage of labor, despite the use of oxytocin. Those women with 100% effacement had consistently faster rates of cervical dilation compared with those at less than 100% (Tables 5–6).

Discussion

Labor is defined as “uterine contractions that bring about demonstrable effacement and dilation of the cervix.” (12) While labor involves both dilation and effacement, existing labor curves demonstrate only the rate of cervical change in relationship to cervical dilation (1–4). We sought to investigate how cervical effacement might influence expectations of the rate of cervical change. In this large cohort of nulliparous women, the rate of cervical dilation in labor was significantly associated with achieving 100% cervical effacement.

Much attention has been paid to when the transition to active labor begins. The CSL data suggest that active labor may not begin until 6 cm (1, 6). This strict criterion, however, has been challenged by Cohen and Friedman who “discouraged the use of any specific degree of dilation for the identification of the active phase” (13). They argue that the timing of active labor depends on assessment of the individual patient, but is typically between 3 and 6 cm. Our observations suggest that combining the assessment of cervical dilation with cervical effacement may allow us to better define the beginning of active labor. If our findings are confirmed, future labor guidelines may wish to include the combination of cervical dilation and effacement when defining active labor.

Our analyses consistently demonstrated that achievement of 100% cervical effacement was associated with faster labor progression. Even when the comparisons did not reach statistical significance, the trend was in this direction. The instances that were not statistically significant occurred in those with spontaneous labor, which were a minority of our cohort. In particular, the availability of data at earlier dilations was scarce in this group, likely secondary to fewer women in spontaneous labor having been admitted to labor and delivery prior to more advanced cervical dilations. Overall, these smaller numbers do limit our ability to comment on this group.

Strengths of this study include the prospective collection of data from a large number of nulliparous women from multiple institutions. However, measuring the rate of labor progress was not the focus of the study, and there was no protocol regarding the frequency of examinations or the experience level of those performing them. The uneven frequency is partially addressed through our statistical methods, but potential observer errors are not. By separating women into those who were 100% effaced vs. not, we hoped to eliminate some of the inter-observer variability that is inherent in measuring cervical effacement (9, 10). This decision was designed to provide more-reproducible results, while allowing us to provide insight into how cervical effacement is associated with labor progression.

While those who have cesarean deliveries for arrest disorders have slower labor progression, we wished to address the basic question regarding cervical effacement in this group as well. Therefore, we repeated the analysis in this group and found that the pattern of more rapid cervical dilation was associated with achievement of 100% cervical effacement in these women as well. While the absolute range of time to dilate from one centimeter to the next may differ between those with a vaginal or cesarean delivery, the association between rate of cervical change and 100% cervical effacement was consistently observed.

Our study is applicable only to women who share characteristics with the women in the original study. We do not have data on multiparous women or diabetic women. Also, our analysis was limited to those who arrived at the hospital and agreed to participate in the randomized trial before reaching 7 cm dilation. Those missed would include women whose labor was progressing more quickly and therefore without sufficient opportunity to enroll in the trial. The result is an unknown lengthening of the time we report for labor progression. Lastly, those who chose to participate in the randomized trial may be different from those who did not.

Finally, our analysis combined women who had labor inductions with those who had labor augmentations. This was done because the distinction between these groups can be difficult to make and there is likely substantial overlap. The combination of these two groups is supported by the findings by Harper and colleagues who analyzed the labor progress of women with augmented and induced labors and found them to be similar (14).

Labor involves a complex process of both cervical dilation and effacement. As we strive to safely reduce the number of unnecessary cesarean deliveries, we hope that an understanding of how cervical effacement may impact the expected rate of cervical change in labor will allow clinicians to more appropriately diagnose arrest disorders.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Table 1

Patient demographics and labor characteristics *

Characteristic	Overall (n=3.902)	Induced/Augmented (n=1,466/1.948)	Spontaneous (n=488)	p-value†
Maternal race				<0.001
Black or African American	1,190 (30.5%)	1,051 (30.8%)	139 (28.5%)	
White	2,041 (52.3%)	1,856 (54.4%)	185 (37.9%)	
Other	671 (17.2%)	507 (14.9%)	164 (33.6%)	
Ethnicity				
Hispanic/Latina	952 (24.4%)	756 (22.1%)	196 (40.2%)	<0.001
Maternal age (years)	23.0 ± 5.2	23.3 ± 5.3	21.6 ± 4.6	<0.001
BMI at end of pregnancy (kg/m^2)				<0.001
18.5–24.9	500 (12.9%)	405 (12.0%)	95 (19.6%)	
25–29.9	1,452 (37.5%)	1,263 (37.3%)	189 (39.1%)	
30–34.9	1,152 (29.8%)	1,026 (30.3%)	126 (26.0%)	
>=35	767 (19.8%)	693 (20.5%)	74 (15.3%)	
Mean/s.d.	30.9 ± 5.9	31.1 ± 5.9	29.8 ± 5.8	
Gestational age at delivery (weeks)	39.7 ± 1.3	39.7 ± 1.3	39.5 ± 1.2	<0.001
Regional anesthesia	3,695 (94.7%)	3,302 (96.7%)	393 (80.5%)	<0.001
Initiated before randomization	3,349 (85.8%)	3,027 (88.7%)	322 (66.0%)	<0.001
Delivery method				0.002
Spontaneous vaginal	3,122 (80.0%)	2,708 (79.3%)	414 (84.8%)	
Forceps	456 (11.7%)	403 (11.8%)	53 (10.9%)	
Vacuum	324 (8.3%)	303 (8.9%)	21 (4.3%)	
Dilation at first exam (cm)	3 [2–4]	2 [1–3]	4 [3–4]	<0.001
Effacement at first exam (%)	75 [50–90]	75 [50–90]	90 [80–100]	<0.001
Number of cervical exams per patient	6 [5–8]	7 [5–8]	5 [4–6]	<0.001
Time from one exam to the next (mins)	89 [52–140]	90 [52–140]	80 [45–125]	<0.001
Birth weight (grams)	3,315 ± 445	3,323 ± 448	3,265 ± 421	0.001

BMI, body mass index

*Data are mean ± standard deviation, n (%), or median [interquartile range]

†Comparing induced and augmented vs. spontaneous labors. Continuous variables compared using the Wilcoxon rank-sum test and categorical variables using the chi-square test.

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Table 2

Median time (minutes) to increase to the next centimeter cervical dilation, comparing those completely effaced with those less than completely effaced.[*]

	Induced/Augmented Labor (n=3,414)					Spontaneous Labor (n=488)				
Cervical dilation interval (cm)	**N[†]**	**100% effaced *median (5th–95th percentile)***	**N[†]**	**<100% effaced *median (5th–95th percentile)***	**p-value[‡]**	**N[†]**	**100% effaced *median (5th–95th percentile)***	**N[†]**	**<100% effaced *median (5th–95th percentile)***	**p-value[‡]**
2–3	90	34.8 (5.2–232.6)	1655	90.6 (13.6–605.5)	<0.001	16	39.6 (10.2–154.1)	77	37.6 (9.7–146.2)	0.89
3–4	293	38.5 (6.9–216.5)	2385	84.1 (15.0–472.6)	<0.001	47	32.7 (8.0–134.5)	180	40.2 (9.8–165.5)	0.39
4–5	707	40.8 (6.9–242.3)	2533	80.6 (13.6–477.9)	<0.001	137	41.4 (8.0–215.2)	258	59.5 (11.4–309.0)	0.01
5–6	1194	38.2 (6.0–243.4)	2191	72.7 (11.4–463.7)	<0.001	223	32.1 (6.0–173.5)	243	56.7 (10.5–306.1)	<0.001
6–7	1720	31.5 (4.9–203.1)	1693	61.6 (9.5–397.7)	<0.001	321	33.7 (6.8–168.1)	167	57.2 (11.5–285.2)	<0.001
7–8	1974	24.5 (3.4–174.4)	1440	52.2 (7.3–371.6)	<0.001	339	27.0 (4.6–157.9)	149	43.6 (7.5–254.8)	<0.001
8–9	2285	19.2 (2.6–140.2)	1129	44.8 (6.1–327.0)	<0.001	376	22.4 (3.8–130.4)	112	41.8 (7.2–243.4)	<0.001
9–10	2738	17.5 (2.3–132.2)	676	44.2 (5.9–333.2)	<0.001	427	15.9 (2.4–106.4)	61	47.4 (7.1–317.8)	<0.001

[*] Effacement assessed at the earlier of any two successive examinations.

[†] Represents the number of women with available cervical measurement data at the specified range of cervical dilation and level of effacement. Note that the effacement was assessed at the earlier of any two successive examinations, and therefore may have been measured before the lower end of the interval if no examination was performed at the lower end itself.

[‡] Compares those completely effaced with those not yet completely effaced using interval-censored regression and a Wald test.

Table 3

Median time (minutes) to increase to the next centimeter cervical dilation, comparing those completely effaced with those less than completely effaced, with adjustment for maternal body mass index, race, age, and use of epidural anesthesia.[*]

	Induced/Augmented Labor (n=3,387)[†]					Spontaneous Labor (n=484)[†]				
Cervical dilation interval (cm)	**N[‡]**	**100% effaced *median (5th–95th percentile)***	**N[‡]**	**<100% effaced *median (5th–95th percentile)***	**p-value[§]**	**N[‡]**	**100% effaced *median (5th–95th percentile)***	**N[‡]**	**<100% effaced *median (5th–95th percentile)***	**p-value[§]**
2–3	90	36.2 (5.6–234.5)	1645	92.5 (14.3–598.8)	<0.001	16	39.5 (10.8–143.7)	76	36.3 (10.0–132.4)	0.93
3–4	293	39.4 (7.2–216.5)	2363	85.4 (15.6–468.6)	<0.001	47	33.6 (9.0–126.2)	179	39.4 (10.5–147.8)	0.23
4–5	703	42.5 (7.5–241.0)	2510	83.0 (14.6–470.9)	<0.001	135	41.5 (8.2–210.4)	257	60.6 (12.0–307.0)	0.01
5–6	1186	40.1 (6.6–242.8)	2172	75.4 (12.5–456.3)	<0.001	220	33.0 (6.3–171.9)	242	58.3 (11.2–303.6)	<0.001
6–7	1705	32.4 (5.2–203.2)	1681	62.7 (10.0–394.1)	<0.001	317	35.9 (7.7–167.7)	167	59.0 (12.6–276.0)	<0.001
7–8	1956	25.2 (3.6–174.1)	1431	53.1 (7.7–367.6)	<0.001	335	29.0 (5.3–158.8)	149	44.9 (8.2–245.4)	0.001
8–9	2264	19.6 (2.7–140.7)	1123	45.3 (6.3–324.7)	<0.001	372	24.0 (4.4–131.3)	112	42.9 (7.8–234.5)	<0.001
9–10	2713	17.9 (2.4–132.7)	674	44.8 (6.0–332.3)	<0.001	423	16.5 (2.5–106.7)	61	48.4 (7.5–313.7)	<0.001

[*] Effacement assessed at the earlier of any two successive examinations.

[†] Thirty-one women (27 with induced or augmented labor; 4 with spontaneous labor) are not included in this analysis due to missing data for maternal body mass index.

[‡] Represents the number of women with available cervical measurement data at the specified range of cervical dilation and level of effacement. Note that the effacement was assessed at the earlier of any two successive examinations, and therefore may have been measured before the lower end of the interval if no examination was performed at the lower end itself.

[§] Compares those completely effaced with those not yet completely effaced using interval-censored regression and a Wald test.

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Table 4

Median time (minutes) to reach 10 cm of cervical dilation from 4, 5, and 6 cm respectively, comparing those completely effaced versus less than completely effaced.*

	Induced/Augmented Labor (n=3,414)					Spontaneous Labor (n=488)				
Cervical dilation change (cm)	**N†**	**100% effaced *median (5th–95th percentile)***	**N†**	**<100% effaced *median (5th–95th percentile)***	**p-value‡**	**N†**	**100% effaced *median (5th–95th percentile)***	**N†**	**<100% effaced *median (5th–95th percentile)***	**p-value ‡**
4–10	591	304.0 (122.1–757.0)	1881	370.4 (148.8–922.3)	<0.001	117	299.0 (144.2–619.6)	192	340.1 (164.1–704.8)	0.01
5–10	849	224.4 (79.4–634.2)	1139	255.3 (90.3–721.7)	<0.001	142	199.5 (87.0–457.7)	117	238.3 (103.9–546.5)	0.005
6–10	1079	150.3 (45.9–492.7)	663	178.0 (54.3–583.3)	<0.001	230	145.6 (52.5–403.8)	84	167.9 (60.5–465.7)	0.07

*Effacement assessed at the earlier of any two successive examinations. Each row of the table includes only those women with a cervical measurement at the starting dilation (i.e., 4, 5, or 6 centimeters).

†Represents the number of women with available cervical measurement data at the specified range of cervical dilation and level of effacement. Effacement is classified per the examination at the start of the dilation interval.

‡Compares those completely effaced with those not yet completely effaced using right-censored regression and a Wald test.

Table 5

Median time (minutes) to increase to the next centimeter cervical dilation among 985 women with induced or augmented labor who had a cesarean delivery for dystocia, comparing those completely effaced with those less than completely effaced. *

Cervical dilation interval (cm)	N†	100% effaced *median (5th–95th percentile)*	N†	<100% effaced *median (5th–95th percentile)*	p-value‡
2–3	28	50.0 (7.1–353.2)	601	111.4 (15.8–786.7)	0.007
3–4	89	48.6 (8.5–279.6)	741	102.4 (17.8–589.2)	<0.001
4–5	201	80.3 (15.8–407.1)	626	108.4 (21.4–549.8)	0.001
5–6	264	55.7 (9.2–335.9)	376	86.0 (14.3–518.3)	<0.001
6–7	290	46.8 (7.9–276.4)	180	78.5 (13.3–463.9)	<0.001
7–8	260	38.5 (6.5–227.6)	104	63.0 (10.7–372.3)	0.001
8–9	241	26.5 (4.4–158.4)	53	61.6 (10.3–367.8)	<0.001
9–10	199	32.5 (5.8–182.1)	13	100.5 (18.0–562.5)	<0.001

*Cesarean delivery for arrest disorders from both the first and second stages of labor. Effacement assessed at the earlier of any two successive examinations.

†Represents the number of women with available cervical measurement data at the specified range of cervical dilation and level of effacement. Note that the effacement was assessed at the earlier of any two successive examinations, and therefore may have been measured before the lower end of the interval if no examination was performed at the lower end itself.

‡Compares those completely effaced with those not yet completely effaced using interval-censored regression and a Wald test.

Table 6

Median time (minutes) to increase to the next centimeter cervical dilation among 974 women who had a cesarean delivery for dystocia, comparing those completely effaced versus with those than completely effaced, with adjustment for maternal body mass index, race, age, and use of epidural anesthesia. [*]

Cervical dilation interval (cm)	N[†]	100% effaced *median (5th–95th percentile)*	N[†]	<100% effaced *median (5th–95th percentile)*	p-value[‡]
2–3	28	54.0 (8.0–364.0)	593	116.2 (17.2–783.3)	0.01
3–4	87	49.2 (8.6–280.6)	733	102.5 (18.0–583.9)	<0.001
4–5	197	82.1 (16.6–406.5)	620	109.6 (22.1–542.9)	0.002
5–6	259	58.2 (10.1–334.4)	372	88.8 (15.4–510.2)	<0.001
6–7	286	48.4 (8.5–276.6)	178	79.4 (13.9–453.5)	<0.001
7–8	256	39.5 (6.8–228.9)	103	63.1 (10.9–365.9)	0.003
8–9	237	26.4 (4.4–158.9)	53	61.5 (10.2–369.8)	<0.001
9–10	196	31.9 (5.6–180.4)	13	100.1 (17.7–565.6)	0.001

[*]Cesarean delivery for arrest disorders from both the first and second stages of labor. Effacement assessed at the earlier of any two successive examinations. Body mass index was unavailable for 11 women, and as a result do not appear in this table.

[†]Represents the number of women with available cervical measurement data at the specified range of cervical dilation and level of effacement. Note that the effacement was assessed at the earlier of any two successive examinations, and therefore may have been measured before the lower end of the interval if no examination was performed at the lower end itself.

[‡]Compares those completely effaced with those not yet completely effaced using interval-censored regression and a Wald test.