Epidural Analgesia Lengthens the Friedman Active Phase of Labor

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OBJECTIVE: To estimate the effect of epidural analgesia on the Friedman labor curve.

METHODS: This study was a secondary analysis of a previously reported randomized trial of the effects of patient-controlled epidural analgesia during labor compared with patient-controlled meperidine on cesarean delivery rate. All subjects had a singleton, cephalic, nonanomalous fetus at or beyond 37 weeks' gestation. This secondary analysis was limited to women who had cervical dilatation commencing of at least 3 cm (ie, active phase of labor).

RESULTS: A total of 459 women were randomized. Twenty-five women were excluded for a cervix less than 3 cm dilated, leaving 220 women allocated to patient-controlled epidural analgesia and 214 to patient-controlled intravenous meperidine available for analysis. There were no significant demographic differences between the two groups, including age, race, gestational age, and cervix on admission. The active phase of labor was 1 hour longer in the epidural-treated group (6.0 ± 3.2 hours versus 5.0 ± 3.2 hours, $P < .001$). The rate of cervical dilation was significantly less with epidural analgesia (1.4 cm/h versus 1.6 cm/h, $P < .002$). The duration of the second stage tended to be longer in the epidural group (1.1 ± 1.5 hours versus 0.9 ± 1.0 hours, $P = .079$).

CONCLUSION: Epidural analgesia prolonged the active phase of labor by 1 hour compared with Friedman's original criteria. (Obstet Gynecol 2002;100:46–50. © 2002 by The American College of Obstetricians and Gynecologists.)

Emanuel Friedman[1] began scientifically studying labor in 1954 when he described a characteristic sigmoid pattern for labor when graphing cervical dilatation against time and using statistical analysis to describe the resulting labor curve. This graphical-statistical approach has been used widely for almost 50 years in the United States and elsewhere. More recently, there has been considerable controversy as to whether epidural analgesia causes dysfunctional labor leading to cesarean delivery for dystocia.[2] Our purpose was to analyze the effects of epidural analgesia on labor by using the graphical-statistical techniques of Friedman. We previously reported a randomized investigation of the effects of epidural analgesia on cesarean delivery rates in nulliparous women at term randomly allocated to epidural or intravenous meperidine analgesia.[3] We reasoned that a secondary analysis of these women might allow us to assess the effect of epidural analgesia on Friedman's labor curve.

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MATERIALS AND METHODS

This study is a secondary analysis of a previously published randomized trial of the effects of patient-controlled epidural analgesia during labor compared with patient-controlled intravenous meperidine on cesarean delivery rates.[3] This analysis was limited to women who had a change in cervical dilation commencing with dilatation of at least 3 cm at admission.

The study protocol was developed by investigators from the Departments of Anesthesiology and Obstetrics and Gynecology and approved by the Institutional Review Board of the University of Texas Southwestern Medical Center at Dallas. The study commenced on October 1, 1998, and ended on November 3, 2000. Healthy nulliparous parturients with a singleton cephalic gestation at term and in spontaneous labor were offered participation in this randomized investigation. Women who gave written consent were randomly assigned, using numbered sealed envelopes, to receive either patient-controlled epidural analgesia or patient-controlled intravenous meperidine analgesia at their first request for relief of labor pain. The randomization sequence was computer derived in blocks of 20 subjects.

All pregnancies were treated by certified nurse-midwives under direct supervision by obstetric faculty and house officers according to a written protocol established by the medical staff. Routine intrapartum treatment of all women included intravenous fluid administration and electronic fetal heart rate surveillance for 30 minutes after commencing epidural or intravenous analgesia. Continuous internal electronic fetal heart rate monitor-

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ing was used in women with meconium-stained amnionic fluid, auscultated fetal heart rate decelerations, or inadequate progress of labor. Pelvic examinations were performed at least every 2 hours to evaluate the progress of labor.

Oxytocin augmentation of labor was given for hypotonic uterine contractions (defined as less than 200 Montevideo units using intrauterine pressure transducers) and the absence of cervical change over 2 hours. Oxytocin was administered per written protocol, which has been described previously.[4] Briefly, oxytocin starting at 6 mU/min was increased by 6 mU/min increments at 40-minute intervals up to a maximum of 42 mU/min. Uterine activity of 200–250 Montevideo units for 2–4 hours was considered adequate. Dystocia was diagnosed when adequate uterine activity did not result in progressive cervical dilation or descent of the fetal head. Indications for the use of forceps were limited to inadequate voluntary pushing or fetal heart rate abnormalities. Inadequate voluntary pushing was determined at the bedside when lack of fetal descent because of inadequate maternal expulsive efforts was observed.

Women randomly assigned to patient-controlled epidural analgesia received an intravenous bolus of 500 mL of Ringers lactate after which analgesia was initiated using an indwelling catheter inserted into the lumbar epidural space via a 17-guage Touhy needle. Analgesia was achieved with 3-mL increments of 0.25% bupivacaine to a bilateral T-10 sensory level after a negative test dose. Epidural analgesia was maintained with 0.0625% bupivacaine and fentanyl 2 μg/mL at 5 mL per hour with 4-mL boluses every 15 minutes as needed using a patient-controlled analgesia pump (Abbott Pain Manager APM 11, Abbott Laboratories, North Chicago, IL). This was maintained throughout the first stage of labor. If progress during the second stage of labor was inadequate after 1 hour, the infusion was halved. If labor progress continued to be inadequate after 2 hours, the infusion was discontinued.

Women randomly assigned to patient-controlled intravenous meperidine received 50 mg of meperidine with 25 mg of promethazine hydrochloride intravenously as an initial bolus, followed with a patient-controlled pump (Abbott Lifecare 4100l; Abbott Laboratories, North Chicago, IL) that delivered 15 mg of meperidine every 10 minutes as needed until delivery. Additional 25-mg doses of meperidine were given on request not to exceed 100 mg in 2 hours. Epidural analgesia was administered when the patient deemed her pain relief unacceptable.

The active phase of labor was defined to begin when a change in cervical dilation was diagnosed commencing with cervical dilatation of 3 cm on admission.[3] The second stage of labor was diagnosed at complete cervical dilatation and ended with delivery of the infant. The rate of change in cervical dilation (cm/h) was calculated for the interval from diagnosis of active phase of labor to the maximum observed cervical dilatation.

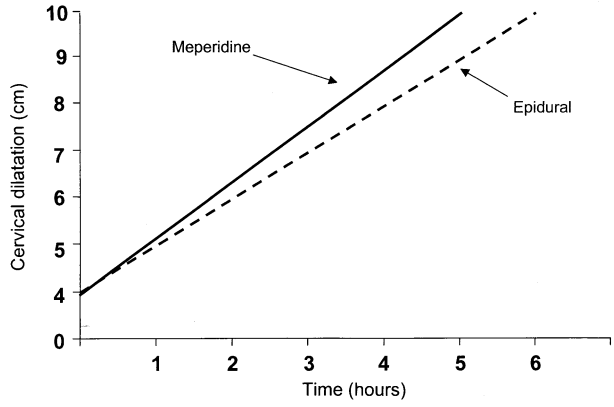

Figure 1. Rate of cervical dilation during the active phase of labor in women with epidural versus meperidine analgesia.

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All statistical analyses were performed on an intent-to-treat basis, and all tests of significance were performed using two-tailed tests. Data were analyzed using SAS statistical software 8.2 (SAS Institute, Inc., Cary, NC). Statistical significance ($P < .05$) was determined using unpaired Student t test, Pearson χ^2 test, and Mann-Whitney U test as indicated. A Shapiro-Wilk test was used to examine normality assumptions.

The labor curves presented (Figures 1 and 2) are representations of the change in cervix over time for the groups as estimated by standard two-stage regression, often referred to as the National Institutes of Health method.[5] This method estimates the change in cervix for each patient using ordinary least-squares regression and averages these slopes for the subgroup of interest to estimate the summary statistics for each group. In women who had cesarean delivery, we used the cervical examination at the time the decision was made for performing the cesarean delivery.

RESULTS

A total of 459 women were included, and 226 women were allocated to receive patient-controlled epidural analgesia, and 233 received patient-controlled intravenous meperidine in the primary analysis. As shown in Table 1, 220 women who were randomly assigned to epidural

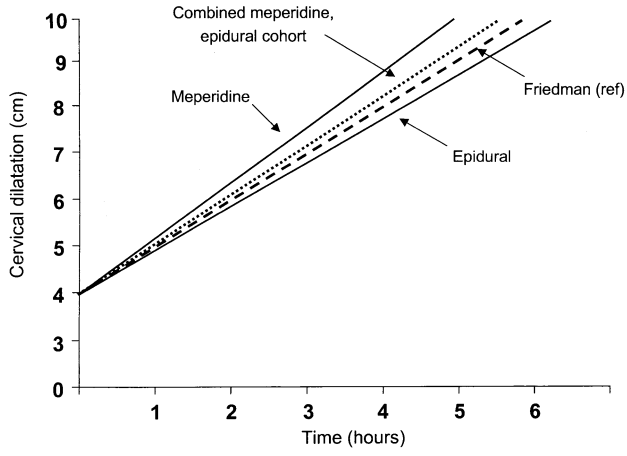

Figure 2. Comparison of the rates of cervical dilation during the active phase of labor originally reported by Friedman[6] and now reported for the women who received patient-controlled intravenous meperidine, patient-controlled epidural analgesia, and the combined cohort.
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analgesia and 214 who were randomly assigned to intravenous meperidine met the inclusion criteria for this secondary analysis. No women randomly assigned to epidural received meperidine; however, 14 women who received meperidine requested and "crossed over" to epidural. There were no significant demographic differences among the study participants (Table 1). Labor complications, including oxytocin augmentation and forceps delivery, were significantly higher in women given epidural analgesia (Table 2). The overall cesarean delivery rate, as well as the indications for cesarean births, was not different between the two analgesia groups. Seventy-four percent of women in the study had internal fetal heart rate monitoring according to our protocol, which allows intermittent monitoring in uncomplicated labors.

The duration of labor was analyzed according to the type of analgesia used, and the results are presented in Table 3 both as means (± standard deviation) and medians (first and third quartiles). Mean values are presented to coincide with other reports on labor duration; median results are also provided because labor times are not normally distributed. The number of examinations performed in each group was the same and consistent with our protocol of cervical examination every 2 hours (3.3 ± 1.7 in the meperidine group versus 3.5 ± 1.6 in the epidural group, $P = .06$). The active phase of labor was 1 hour longer in the epidural group compared with the meperidine group (mean 6.0 ± 3.2 hours versus 5.0 ± 3.2 hours, respectively, $P < .001$). The rate of cervical dilation was significantly lower with epidural analgesia (1.4 cm/h versus 1.6 cm/h, epidural versus meperidine, respectively, $P < .002$). Figure 1 shows the rate of cervical dilation for women with epidural or meperidine analgesia. The mean duration of the second stage of labor was 1.1 ± 1.5 hours in women given epidural analgesia compared with 0.9 ± 1.0 hours in women given meperidine ($P = .079$). The rate of cervical dilation for the active phase of labor was 1.4 cm/h compared with 1.6 cm/h, epidural analgesia compared with meperidine, respectively ($P < .002$).

To describe true undisturbed parturition, Friedman reported an idealized series of women without complications who had vaginal delivery.[6] Table 4 is a similar analysis of women who had spontaneous labor and delivery as well as those given oxytocin. An epidural effect on the active phase was still seen in this group of women; however, this effect is lost in women who had oxytocin augmentation.

Table 1. Maternal Demographics in Women Randomly Assigned to Receive Patient-Controlled Epidural Analgesia or Patient-Controlled Intravenous Meperidine During the Active Phase of the First Stage of Labor

Characteristics	Epidural analgesia ($n = 220$)	Meperidine analgesia ($n = 214$)	P
Age (y)	20.8 ± 4.0	20.8 ± 3.8	.99
Gestational age (wk)	39.3 ± 1.3	39.2 ± 1.5	.58
Race			.62
Hispanic	184 (84)	186 (87)	
Black	26 (12)	23 (11)	
White	6 (3)	3 (1)	
Other	4 (2)	2 (1)	
Cervix at admission			
Dilatation (cm)	4.1 ± 1.0	4.2 ± 1.0	.17
Effacement (%)	87.6 (11.7)	87.2 (11.6)	.72
Fetal station at admission (cm)	−1.0 ± 1.1	−1.0 ± 0.9	.68

Data are presented as mean ± SD or *n* (%).

Table 2. Labor Complications and Delivery Method in Women Randomly Assigned to Receive Epidural Versus Meperidine Analgesia During Labor

Labor outcome	Epidural analgesia (n = 220)	Meperidine analgesia (n = 214)	P
Oxytocin augmentation	97 (44)	68 (32)	.009
Spontaneous delivery	181 (82)	196 (92)	.004
Forceps delivery	27 (12)	6 (3)	.003
Cesarean delivery			
Total	12 (5)	12 (6)	.94
Dystocia	9 (4)	11 (5)	.60
Nonreassuring fetal heart rate	3 (1)	1 (1)	.33

Data are n (%).

DISCUSSION

The primary finding in this study was that the rate of cervical dilation was significantly slower in women who had epidural analgesia, resulting in a longer active phase of labor compared with Friedman's original data. Importantly, this effect of epidural analgesia was not seen with oxytocin-stimulated labor. The second stage of labor tended to be longer in women treated with epidural anesthesia (mean 1.1 hours versus 0.9 hours, epidural versus meperidine group, respectively, P = .079). It should be mentioned, however, that forceps were used significantly more often in deliveries of epidural-treated women. This finding minimizes any effect epidural analgesia might have had on prolonging the length of the second stage.

Our results on the rate of cervical dilation in the active phase of labor are consistent with those originally reported by Friedman.[6] In Figure 2 the rates of cervical dilation during the active phase of labor in our overall cohort are compared with those originally reported by Friedman.[6] Although our analysis did not reveal a deceleration phase, the rates of cervical dilation are virtually identical, suggesting that our finding of epidural-related slowing of the active phase of labor is not a result of misapplication of Friedman's criteria for graphical-statistical analysis of labor.

The mechanism by which epidural analgesia might inhibit or impede the active phase of labor is not known. One hypotheses is that epidural analgesia results in suppression of prostaglandin $F_2\alpha$ release, leading to diminished uterine contractility and prolongation of the active phase of labor.[7] The proposed mechanism for this hypothesis is the observation that prostaglandin production is required for the progression of uterine contractions.[8] Additional evidence, albeit indirect, for an epidural effect on uterine contractility is our previously reported observation that women given epidural analgesia during the active phase of labor require a greater dose of oxytocin to effect cervical dilation compared with women given meperidine.[9] The study now reported is consistent with that prior observation. The effect of epidural analgesia on Friedman's criteria appears to be minimized in the presence of oxytocin augmentation, as shown in Table 4.

In conclusion, epidural analgesia given during the active phase of labor significantly increased the length of

Table 3. Duration of Labor in Women Randomly Assigned to Receive Epidural Versus Meperidine Analgesia

Labor	Epidural analgesia (n = 220)	Meperidine analgesia (n = 214)	P
Active phase (h)			<.001
Mean ± SD	6.0 ± 3.2	5.0 ± 3.2	
Median (1st and 3rd quartiles)	5.2 (3.9, 8.0)	4 (2.7, 7)	
Second stage (h)			.078
Mean ± SD	1.1 ± 1.5	0.9 ± 1.0	
Median (1st and 3rd quartiles)	0.8 (0.4, 1.3)	0.6 (0.3, 1.2)	
Rate of cervical dilatation (cm/h)			.002
Mean ± SD	1.4 ± 1.5	1.6 ± 1.2	
Median (1st and 3rd quartiles)	1.0 (0.7, 1.5)	1.25 (0.8, 2)	
Total* (h)			<.001
Mean ± SD	7.1 ± 3.7	5.9 ± 3.6	
Median (1st and 3rd quartiles)	6.4 (4.4, 9.4)	5.1 (3.2, 7.8)	

SD = standard deviation.

* Total = length of time from the beginning of the active phase of labor plus the second stage.

Table 4. Effects of Epidural Analgesia Versus Meperidine on Duration of Labor in Women With Spontaneous Labor and Vaginal Deliveries After Spontaneous or Oxytocin-Augmented Labor

	Spontaneous labor		Oxytocin augmentation	
Labor	Epidural analgesia (n = 106)	Meperidine analgesia (n = 138)	Epidural analgesia (n = 75)	Meperidine analgesia (n = 55)
Active phase (h)				
Mean ± SD	4.9 ± 2.4	3.8 ± 2.3	7.4 ± 3.5	7.0 ± 3.4
Median (1st and 3rd quartiles)	4.9 (3.5, 6.1)	3.5 (2, 5)	7 (4.8, 10.0)	6.0 (4, 9.7)
	$P < .001$		$P = .50$	
Rate of cervical dilatation (cm/h)				
Mean ± SD	1.6 ± 1.9	1.9 ± 1.3	1.1 ± 0.8	1.1 ± 0.8
Median (1st and 3rd quartiles)	1.2 (0.9, 1.6)	1.5 (1, 2.5)	0.8 (0.6, 1.2)	0.9 (0.7, 1.5)
	$P = .001$		$P = .41$	
Second stage (h)				
Mean ± SD	1.0 ± 1.3	0.7 ± 0.5	1.0 ± 1.4	0.9 ± 1.0
Median (1st and 3rd quartiles)	0.7 (0.4, 1.1)	0.6 (0.3, 0.9)	0.8 (0.5, 1.2)	0.7 (0.3, 1.3)
	$P = .046$		$P = .64$	
Total (h)				
Mean ± SD	5.9 ± 2.8	4.5 ± 2.4	8.4 ± 3.9	7.9 ± 3.8
Median (1st and 3rd quartiles)	5.6 (4.1, 7.3)	4.1 (2.7, 5.7)	8 (5.3, 11.1)	7.6 (4.6, 10.3)
	$P < .001$		$P = .42$	

SD = standard deviation.

labor, but the effect was small. The importance of this finding should be viewed in the context of concerns that a major contribution to the use (and abuse) of cesarean delivery for dystocia in the United States is rapid diagnosis of dystocia.[10] Given the widespread use of epidural analgesia in approximately two thirds of American women during labor, obstetricians should be cognizant of the potential of epidural analgesia to interfere with the active phase of labor without affecting overall cesarean delivery rates (Hawkins JL. Abstract A 1060. Update on US OB anesthesia practices 1999;91:3A). Not recognizing this effect potentially leads to a falsely prompt diagnosis of dystocia leading to an otherwise avoidable cesarean delivery.

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