Local Anesthetic Requirements Are Greater in Dystocia Than in Normal Labor

Moeen K. Panni, M.D., Ph.D.,* Scott Segal, M.D.†

Background: Dystocia is characterized by abnormal progress of labor and is a common contemporary indication for cesarean delivery in the United States. There has been considerable controversy as to whether epidural analgesia causes dysfunctional labor leading to cesarean delivery for dystocia. The minimum local analgesic concentration (MLAC) is a clinical model used to determine the relative potencies of local anesthetics in the first stage of labor. In this article, the authors report a prospective study determining the MLAC of bupivacaine in early labor of parturients who eventually delivered either vaginally or via cesarean section.

Methods: An up-down sequential allocation technique was used to determine the MLAC of bupivacaine in 57 nulliparous parturients assigned to either vaginal delivery or cesarean section arms. In addition, patients were assigned to groups receiving or not receiving intravenous oxytocin at the time of epidural placement. Only patients who delivered by the assigned delivery mode were included in the MLAC analyses.

Results: Parturients who later delivered vaginally had 25% and 31% lower MLAC values (0.078% and 0.085% wt/vol bupivacaine, receiving or not receiving intravenous oxytocin, respectively) than those who later delivered by cesarean section (0.102% and 0.106% wt/vol bupivacaine, receiving or not receiving intravenous oxytocin, respectively).

Conclusions: These data suggest that an increased local anesthetic requirement for epidural labor analgesia is associated with more intense pain related to dystocia. Women in early, clinically normal labor but who later develop dystocia require more local anesthetic and, by inference, are experiencing more severe pain than women who deliver vaginally. This association should be considered when studying the relation between the method of labor analgesia and the course of labor.

DYSTOCIA is characterized by abnormal progress of labor and is a common indication for cesarean section. There has been considerable controversy as to whether epidural analgesia leads to abnormal labor and results in cesarean section for dystocia. A number of studies supporting this are based on retrospective analyses that suffer from selection bias.1–4 Women seeking epidural pain relief may have more difficult labors with other maternal or fetal risk factors for dystocia and hence have cesarean sections for these reasons alone. Recent studies have suggested that women with more intense labor pain, who are more likely to request epidural analgesia when it is freely available, may have an increased intrinsic risk of cesarean delivery for dystocia as severe pain may be an indication of obstructed labor.5–7 Few of these studies have measured pain scores or initial local anesthetic requirements prospectively prior to the diagnosis of dystocia. Instead, they have retrospectively related indirect measures such as local anesthetic or opioid consumption with mode of delivery.

To evaluate the pharmacodynamics of various epidural analgesics, the minimum local analgesic concentration (MLAC) model was developed to determine the relative potencies of local anesthetics in the first stage of labor.8–11 This technique has also been used to estimate the local anesthetic sparing potential of epidural opioids,12–14 the differential effect of intravenous and epidural opioids,15 and the contribution of the state of cervical dilatation on local anesthetic requirements.16 The MLAC has thus been defined as the median effective local anesthetic concentration during the first stage of labor.

In this article, we report a prospective study determining the MLAC of bupivacaine in early labor in parturients who later delivered either vaginally or via cesarean section for dystocia. We modified the usual up-down sequential allocation technique of determining MLAC in early labor by including an additional criterion for accepting or rejecting a given woman’s data in the up-down sequence, namely, the mode of delivery. We hypothesized that the MLAC and, by inference, pain would be higher in parturients who eventually experience dystocia and require cesarean section than in those who deliver vaginally.

Materials and Methods

Patients

This research was conducted at Brigham and Women’s Hospital (Boston, Massachusetts) during July to December 2001. After obtaining approval from the institutional review board and obtaining written informed consent, 148 nulliparous patients who requested epidural analgesia for labor were approached for participation in the study. All patients met the following entry criteria: American Society of Anesthesiologists physical status I or II,
singleton pregnancies of greater than 36 and less than 41 weeks’ gestation, vertex fetal presentation, spontaneous onset of labor, and cervical dilation between 3 and 5 cm at the time of the most recent cervical examination. The patient’s obstetrician or midwife was consulted prior to epidural placement to verify that the labor pattern was clinically judged to be normal, including adequate contraction frequency and strength and progressive cervical change. Exclusion criteria included the attending obstetrician’s clinical diagnosis of dystocia, receipt of opioid or sedative medication in the 4 h prior to epidural placement, a history of substance abuse, preeclampsia, macrosomia, nonreassuring fetal heart rate tracing, or abnormal biophysical profile or oxytocin stress test. In addition, if the request for epidural placement occurred prior to the onset of active labor as defined on clinical grounds by the obstetric practitioner or if the initial visual analog pain score (VAPS) prior to epidural placement was less than 30, the patient was not included in the study.

**Study Arms**

Eligible patients were assigned to one of four study groups. First, patients were divided based on whether they were receiving oxytocin at the time of request for epidural analgesia. Next, the patients were assigned on alternate study days to a spontaneous vaginal delivery group or a cesarean section for dystocia group. The study design necessarily resulted in different group sizes for the vaginal and cesarean section arms (see details of modified MLAC method, below). Consequently, after completion of the vaginal delivery arms, which were more efficiently performed, all remaining patients were assigned to the cesarean section arms. The assignment was made prior to the knowledge of the actual delivery mode and was not based on any assessment of the patient’s labor pattern. The actual delivery mode was used in the algorithm for determining the median effective local anesthetic concentrations (see details of MLAC method, below). Thus, there were four study groups in this investigation: (1) spontaneous vaginal delivery, not receiving oxytocin at epidural placement; (2) spontaneous vaginal delivery, receiving oxytocin at epidural placement; (3) cesarean section for dystocia, not receiving oxytocin at epidural placement; and (4) cesarean section for dystocia, receiving oxytocin at epidural placement.

**Epidural Technique**

Following intravenous prehydration with 500–1,000 ml lactated Ringer’s solution, patients were placed in the flexed sitting position. After raising a midline skin wheal with 1% wt/vol lidocaine, the epidural space was identified using loss of resistance to air at the L2–L3 or L3–L4 level, and a multi-hole epidural catheter was advanced 5 cm into the epidural space. No test dose was used other than the study solution. Each patient received 20 ml bupivacaine in four 5-ml boluses over 5–10 min. The concentration of bupivacaine was determined by the MLAC protocol (see “MLAC Determination,” below). Each study solution was freshly prepared by the operating room pharmacist using preservative-free saline as the diluent to achieve the desired concentration at room temperature (20°C). After catheters were inserted, patients were placed in the supine position with left uterine displacement and 30° elevation of the head of the bed. The injectate was given within 5–10 min of the catheter placement. Patients were monitored using a noninvasive blood pressure monitor, pulse oximeter, and tococardiograph. Efficacy of the study drug was assessed by an investigator unaware of the study solution’s concentration using 100-mm VAPS, where 0 represented “no pain” and 100 was “worst possible pain,” at epidural placement and 10-min intervals following placement for the first 30 min after bolus injection. A VAPS of 10 mm or less achieved during the 30-min study period was defined as effective.

At 30 min, participants who had not achieved effective analgesia were given a rescue bolus of 6–12 ml bupivacaine, 0.25%. Those who did not respond to a rescue dose within 15 min with a VAPS of less than 10 mm were designated as “rejects,” and no change in concentration resulted for the next patient (see details of MLAC methodology, below). Further management then included adjustment or replacement of the epidural catheter with further dosing of epidural bupivacaine. If the 20-min pain score was substantially worse than that prior to epidural placement (VAPS 20% greater than first pain score), a rescue dose was given early (20 min) to prevent prolonged patient discomfort in the setting of an obviously ineffective dose or catheter. As soon as the patients achieved comfort (VAPS < 10 mm), the epidural infusion was started using the standard solution at our institution (0.125% wt/vol bupivacaine with 2 µg/ml fentanyl) at 10 ml/h.

**Minimum Local Analgæsia Concentration Determination**

A modification of the up–down sequential allocation method of determining the median effective local anesthetic concentration was used in this study. A schematic diagram of the modified MLAC method is shown in figure 1. The concentration of local anesthetic received by a particular patient was determined by the response of the previous patient in the same group to a higher or lower concentration, using an up–down sequential allocation technique. The testing interval (the increment or decrement between subsequent patients) was 0.01% wt/vol. The first patient in each group received 0.08% bupivacaine based on previous estimates of MLAC.8–16
DYSTOCIA IS MORE PAINFUL THAN NORMAL LABOR

Fig. 1. Schematic diagram of study design. A traditional minimum local anesthetic concentration (MLAC) up–down sequential allocation design was modified by the inclusion of an additional “reject” criterion, the actual delivery mode. Only those patients delivering by the arbitrarily assigned delivery mode (vaginal delivery or cesarean section) influenced the calculation of MLAC for each arm. VAS = visual analog pain score.

As in the standard MLAC methodology,8–16 three outcomes were considered:

1. Effective: A VAPS of 10 mm or less during contractions was achieved within 30 min of injection. A result defined as effective resulted in a 0.01% wt/vol decrement for the next patient assigned to that group.

2. Ineffective: A VAPS less than 10 mm was not achieved within 30 min of injection, but the patient’s pain responded with a VAPS less than 10 mm to rescue with up to 12-ml bolus of 0.25% bupivacaine. A result defined as ineffective resulted in a 0.01% wt/vol increment for the next patient assigned to that group.

3. Reject: A VAPS greater than 10 mm because of pain that was not responsive within 15 min to additional 0.25% wt/vol epidural bupivacaine rescue (6–12 ml). A result defined as a reject resulted in the same concentration being repeated for the next patient assigned to that group.

Our modification of this standard MLAC methodology included an additional “reject” criterion: a given patient’s data were only considered if she delivered by the assigned mode. A woman assigned to a vaginal delivery arm but who delivered by cesarean section or a woman assigned to a cesarean section arm but who delivered vaginally was therefore designated as a “reject” just as if her epidural catheter had been nonfunctional. We therefore created separate MLAC series for women with normal vaginal deliveries and women who later developed dystocia requiring cesarean section.

Statistical Analysis

Median effective concentrations were estimated from the up–down sequences of included patients using the method of Dixon and Massey17,18 for small n with 95% confidence. This type of analysis (with small n, “nominal sample size” = 5 or 6) was chosen because of the high number of expected rejects (> 80%), with the vast majority of those allocated to cesarean section arms ending up delivering vaginally. The difficulty of recruiting patients not receiving oxytocin at the time of epidural placement (> 75% of nulliparous patients were receiving oxytocin), particularly those who then later developed dystocia, made the expected number of patients required to use the large n method impractically large (estimated additional patients needed > 400).

Analysis of variance was used to confirm the differences between MLAC values, by comparing mean concentrations of local anesthetic used for the patients whose data were used in the MLAC determinations (n = 5 or 6 per group). Logistic regression, using all patients studied except those with ineffective catheters (i.e., including patients rejected because of delivery mode), was used to test the effect of delivery mode. Response to bupivacaine (effective or ineffective) was the dependent variable, and actual delivery mode and concentration of bupivacaine were used as independent variables. A second logistic regression was used to model the determinants of mode of delivery. In this model, mode of delivery was the dependent variable, and response to bupivacaine and concentration were the independent variables. Differences between demographic variables for all included patients were tested with analysis of variance, followed by Student t test with correction for multiple comparisons as appropriate. P < 0.05 was considered statistically significant.

Results

Based on the exclusion criteria, 91 parturients originally enrolled were excluded, most commonly because labor had progressed to greater than 5 cm dilation at the time of epidural request, or did not ever request epidural analgesia. Fifty-seven patients completed the study.

Median effective concentrations were estimated from the up–down sequences using the method of Dixon and Massey for small n17,18 using an assumed SD of 0.028%14 (table 1). Parturients who later delivered vaginally had a 24.7–30.8% lower MLAC (patients not receiving or receiving intravenous oxytocin, respectively) than those who later delivered by cesarean section for dystocia. Figures 2 and 3 show the up–down sequences for each group studied and include rejected patients shown as squares, where the concentration was repeated for the next randomly assigned patient to that group. Analysis of variance of the 23 patients (n = 5 or 6 per group) who collectively represented the nominal samples for the MLAC determinations confirmed the differences between groups (P < 0.0001). The differences between cesarean section and vaginal delivery arms both receiving and not receiving oxytocin were significant (Fisher PLSD test, P < 0.01).

Logistic regression showed both actual delivery mode (P = 0.0264) and concentration (P = 0.0005) to be
highly significant independent predictors of response to bupivacaine. When delivery mode was the dependent variable, logistic regression showed that an ineffective response to bupivacaine (i.e., inadequate analgesia at the tested concentration) was significantly related to the chance of requiring cesarean section (odds ratio, 4.76; \( P = 0.0246 \)).

Demographics of the patients, as assigned to the four arms of the study, are presented in table 2. There were no significant differences between the groups. The number of cesarean sections performed in the patients included in the study (both rejected and accepted) was 29.8% of the total number of included patient deliveries, which is slightly higher than that quoted in national studies of between 20–25% of all deliveries.19 No patient underwent operative vaginal delivery or cesarean section for an indication other than dystocia.

**Discussion**

Our results show that MLAC is higher in early labor for parturients who later deliver by cesarean section as op-

Table 1. MLAC Values for S Arm

<table>
<thead>
<tr>
<th>Study Arm</th>
<th>n (all included and rejected subjects)*</th>
<th>MLAC (% Bupivacaine) [SE]†</th>
<th>95% CI‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaginal delivery, not on oxytocin</td>
<td>8</td>
<td>0.085 [0.0157]</td>
<td>0.045,0.125</td>
</tr>
<tr>
<td>Vaginal delivery, on oxytocin</td>
<td>9</td>
<td>0.078 [0.0157]</td>
<td>0.038,0.118</td>
</tr>
<tr>
<td>Cesarean section, not on oxytocin</td>
<td>20</td>
<td>0.106 [0.0171]</td>
<td>0.059,0.153</td>
</tr>
<tr>
<td>Cesarean section, on oxytocin</td>
<td>20</td>
<td>0.102 [0.0157]</td>
<td>0.066,0.146</td>
</tr>
</tbody>
</table>

* Total n given in the table includes patients whose data were rejected because delivery mode did not match the assigned mode and those with nonfunctional catheters. The nominal sample size (patients whose data influence the calculation of MLAC) was six in all groups except cesarean section not receiving oxytocin, in which it was five. † MLAC is calculated using small n approach of Dixon and Massey17 (see text for details). The difference between delivery modes (cesarean section vs. vaginal delivery) was significant (ANOVA, \( P < 0.0001 \)). ‡ Confidence interval is derived from the MLAC value, the assumed SD of 0.028%, and the appropriate interval from the t distribution. Note that these intervals are wider than if they had been calculated based on the Z distribution, which is reserved for large samples.

CI = confidence interval; MLAC = minimum local anesthetic concentration, SE = Standard error

Fig. 2. Up–down sequences for patients not receiving oxytocin at study entry. Patients in whom the test solution was effective are indicated by triangles, those in whom it was ineffective are indicated by circles, and those in whom the data was not included ("Rejects") are indicated by squares. The minimum local anesthetic concentration (MLAC) estimate is shown by the dotted line. (A) Patients assigned to vaginal delivery. (B) Patients assigned to cesarean section.

Fig. 3. Up–down sequences for patients receiving oxytocin at study entry. Patients in whom the test solution was effective are indicated by triangles, those in whom it was ineffective are indicated by circles, and those in whom the data was not included ("Rejects") are indicated by squares. The minimum local anesthetic concentration (MLAC) estimate is shown by the dotted line. (A) Patients assigned to vaginal delivery. (B) Patients assigned to cesarean section.
DYSTOCIA IS MORE PAINFUL THAN NORMAL LABOR

Table 2. Demographic Variables by Assigned Group

<table>
<thead>
<tr>
<th></th>
<th>CS No Oxytocin (n = 20)</th>
<th>Oxytocin (n = 20)</th>
<th>NSVD No Oxytocin (n = 8)</th>
<th>Oxytocin (n = 9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>27.9 ± 5.0</td>
<td>30.9 ± 4.8</td>
<td>29.8 ± 2.4</td>
<td>29.4 ± 5.3</td>
</tr>
<tr>
<td>Height, cm</td>
<td>165.35 ± 6.1</td>
<td>163.32 ± 7.37</td>
<td>167.39 ± 7.37</td>
<td>166.12 ± 6.1</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>79.7 ± 11.34</td>
<td>80.47 ± 16.65</td>
<td>77.16 ± 10.8</td>
<td>78.06 ± 4.81</td>
</tr>
<tr>
<td>Epidural placement to delivery, min</td>
<td>457.7 ± 158</td>
<td>490.8 ± 312</td>
<td>314.1 ± 144</td>
<td>597.9 ± 428</td>
</tr>
<tr>
<td>Cervical dilation at epidural placement, cm</td>
<td>3.2 ± 1</td>
<td>3.4 ± 0.9</td>
<td>3.9 ± 0.6</td>
<td>3.4 ± 0.9</td>
</tr>
<tr>
<td>Initial VAPS, mm</td>
<td>88.4 ± 12</td>
<td>78.5 ± 15</td>
<td>73.8 ± 17</td>
<td>79.4 ± 14</td>
</tr>
</tbody>
</table>

All values are given as mean ± SD. There were no significant differences between the groups (ANOVA).

CS = cesarean section; NSVD = normal spontaneous vaginal delivery; VAPS = visual analogue pain score.

posed to vaginally. The difference persists at approximately the same magnitude for patients receiving oxytocin at the time of epidural catheter placement and those who were not.

The methodology used in this investigation was novel and bears further explanation. We have modified a traditional up-down sequential allocation technique of determining the MLAC, or EC50, of epidural bupivacaine. In the traditional approach, the concentration of bupivacaine a given patient receives is based on the response of the previous patient in the study. If the response of a given study patient was effective, the next patient receives a slightly decreased concentration. If a given study patient’s response to a concentration was ineffective, the next patient in the series receives slightly more concentrated drug. If the epidural catheter is nonfunctional, defined as no response to additional rescue doses after an “ineffective” response to the concentration tested, this study patient is designated a “reject,” and there is no change in concentration for the next patient in the series.

Our modification of this standard MLAC methodology includes an additional “reject” criterion, which is delivery mode finally achieved by each patient in each series. We assigned patients on alternate study days to a particular delivery mode (spontaneous vaginal delivery or cesarean section) prior to knowing their actual delivery patterns at the time of study enrollment. When a patient delivered, if the mode of delivery was the same as the assigned mode, her data were used as above to determine the next patient’s concentration. If she delivered by a different mode than her assigned one, her data were rejected, just as if her epidural catheter had been nonfunctional (fig. 1). For example, a patient assigned to a vaginal delivery arm but who later delivered by cesarean section was designated a “reject,” regardless of her response to the local anesthetic. Similarly, a patient assigned to a cesarean section but who delivered vaginally (a very common occurrence) was also designated a “reject.” In this way, we separated groups of patients who later delivered vaginally from those who later required cesarean section for dystocia. Only patients who delivered by the assigned delivery mode were able to influence the up-down sequence, and thus determination of MLAC, in each of the four study arms.

Several groups of investigators have determined the MLAC of bupivacaine in earlier studies, with MLAC values being reported from 0.064%,13 0.065%,8 0.067%,9 0.069%,13 0.083%,10 0.091%,20 0.093%,11 and as high as 0.104%.14 The differences between the various MLAC values reported have been attributed to differences in the study populations and the tendency to place epidural catheters at different stages of labor. The importance of timing of epidural placement is crucial with an increase in pain and MLAC values reported as labor progresses, from 0.048% wt/vol in early labor to 0.14% wt/vol in late labor in one study.16 Our MLAC values fall within the range of those reported previously for those patients who go on to deliver vaginally.

The MLAC values were similar in women receiving oxytocin and those who were not in both vaginal delivery and cesarean section arms. This was somewhat surprising as oxytocin infusions are generally believed to increase the pain of labor and epidural analgesic requirement.21 One possibility is that women requiring oxytocin in early labor may be experiencing less forceful contractions than women who do not require it or who require it only later in labor. Recent evidence also demonstrates a modest analgesic effect of oxytocin, which is μ- and κ-opioid mediated.22

Severity of pain in labor may be a marker of dystocia. The intensity of pain is most likely increased when labor is obstructed, but actual reports showing a relation of labor pain to dystocia are rare. Wuitichik et al.5 reported that women who experienced more intense pain in latent labor had longer labors and were more likely to undergo cesarean section delivery. A relation between pain in the active phase of labor and dystocia was not seen. A number of different medications were used for pain relief, and the amount of each used was not quantified. Recently, Hess et al.6 reported that among women with functional epidural catheters, those requiring three or more supplemental epidural boluses were more likely to undergo cesarean or assisted vaginal delivery than were those who required fewer boluses. This retrospec-
tive study did not report direct measurement of patient pain but provided indirect evidence that more intense pain during labor is associated with labor dystocia. Longer labor was also associated with more “top-ups,” and thus, it is possible that the greater number of observed supplemental doses simply reflected this difference and not an actual difference in pain or local anesthetic requirement. The same group reported a follow-up study in which an increased number of top-ups was associated with nulliparity, higher neonatal weight, early epidural placement, and use of epidural versus combined spinal epidural technique for catheter placement. Similarly, another group has reported greater patient-controlled intravenous meperidine use for labor analgesia in women who deliver by cesarean section than in women who deliver vaginally.

In contrast to these earlier efforts, our study offers several advantages. First, this is the first study to measure pain and anesthetic requirements at a fixed point in time, rather than a surrogate calculated over the course of an entire labor. Second, patients were studied well before a diagnosis of dystocia had been made clinically. Third, patient demographics, initial pain score, stage in labor, and use of oxytocin were similar at the time of MLAC measurement. Finally, the analgesics used (20 ml plain bupivacaine) was standardized. Our data do not establish cause or effect, but they strongly suggest that a woman’s analgesic requirement is associated with greater pain related to labor dystocia. This association should be considered when comparing the method of labor analgesia and its potential effects on the course of labor. We show that increased analgesic requirement is likely associated with dysfunctional labor.

There are several potential limitations of our design. First, we chose to use the “small n” approach to calculation of MLAC. This method uses a nominal sample size of 5 or 6 patients after the first “turn” in the up-down sequences and calculates MLAC based on the final value in the sequence, the pattern of the sequence, and an estimate of SD derived from previous studies. In contrast, the “large n” method uses the SD derived only from the data in the current study (which is not necessarily more accurate than previously derived estimates). Because the large majority of patients assigned to a cesarean section arm will instead deliver vaginally and thus be designated “rejects,” performing a “large n” MLAC study with a sample of 25–30 patients per arm would have required an impractically large sample. The “small n” method potentially reduces the precision of our MLAC estimates, though the original authors of the technique consider it the preferred method when the SD is well known from previous work, as is the case with epidural bupivacaine.

A second limitation is the use of alternate-day assignment of patients to the study groups (vaginal delivery or cesarean section). As approximately 80% of patients were expected to deliver vaginally, it necessarily followed that the cesarean section arms of our study would require far more patients to achieve the appropriate nominal sample size. Most patients in the cesarean section arms would be “rejects” because they delivered vaginally. We chose not to randomly assign patients because of this unbalanced group size between the two types of delivery. We do not believe this is likely to have introduced any bias, however, because all patients were judged by their obstetricians to be in normal labor at the time of the study. Furthermore, patients were enrolled into the study prior to the onset of active labor, before a subjective assessment of their pain intensity could bias the investigators. Finally, patient demographics did not vary between the groups (table 2).

Another limitation is our reliance on clinical diagnoses of normal labor at study entry as well as dystocia requiring cesarean section later in labor. It is possible that subclinical dystocia was occurring in some of our patients at the time of epidural initiation and MLAC determination. However, we do not believe this would affect our results since the obstetrician was not aware of the group assignment or the bupivacaine concentration given and therefore could not bias the MLAC sequence. Moreover, one explanation of the higher local anesthetic requirements in patients eventually developing clinical dystocia is that they were already experiencing dysfunctional, more painful labor at the time of their epidural placement. A subjective assessment by the obstetrician was also used to define the need for cesarean section. Certainly clinicians may differ in their conclusions regarding this need. We do not believe this to be a major weakness, however, because dystocia requiring cesarean section is always defined by the obstetrician in clinical practice, and the obstetricians were not aware of the study arm, bupivacaine concentration, or patient response to it.

Finally, the MLAC method measures analgesic requirement to achieve a VAPS of less than 10 mm rather than intensity of pain directly. That is, a patient’s VAPS response to bupivacaine, not her VAPS itself, determines the next patient’s bupivacaine concentration. The relation between pain intensity and bupivacaine requirement is logical but unproven.

The relation between pain and dystocia is not clear and is likely complex. Pain could represent a result of various processes (large baby, pelvic anatomy, presentation of fetal part) that may obstruct labor. Our data are consistent with this possibility. Dystocia itself may be more painful (uncoordinated contraction, contraction without cervical dilatation), which again is consistent with our data. Finally, pain may cause dystocia as studies have shown that blocking maternal catecholamines (with propranolol) speeds progress of labor. We doubt that this last point explains our results as our patients were studied before the diagnosis of dystocia was made.
(though subclinical dystocia at the time of epidural placement cannot be excluded). Moreover, all patients were made comfortable, so invoking ongoing pain as a cause of later dystocia is not possible. Further work is necessary to delineate the mechanisms by which dystocia increases pain.

In summary, we have demonstrated increased local anesthetic requirements in nulliparous patients in early, clinically normal labor who later develop dystocia requiring cesarean section, as compared with those who deliver vaginally.

The authors thank Joan Spiegel, M.D. (Resident, Department of Anesthesiology Perioperative and Pain Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts), for her help in the early planning of this study.

References