Hemodynamic Stability During Labor and Delivery With Continuous Epidural Infusion

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**Context:** Epidural anesthesia for labor pain is frequently complicated by maternal hypotension.

**Objective:** To test whether continuous epidural infusion (CEI) of local anesthetic, without bolus administration, lowers the incidence of hypotension in parturient patients.

**Methods:** In a single-blind clinical study, subjects were randomly assigned to CEI-only (10 mL/h of 0.2% ropivacaine hydrochloride without bolus) or control (10 mL of 0.2% ropivacaine hydrochloride per hour with 10-mL bolus) epidural dosing groups. The incidence of hypotension (20% decrease in systolic blood pressure or mean arterial pressure (MAP), systolic blood pressure lower than 100 mm Hg, or MAP lower than 65 mm Hg) was recorded for 2 hours after dosing. Statistical analysis included a 2×2 χ² analysis, the Fisher exact test, and paired two-tailed t tests.

**Results:** Fifty subjects were studied, with 25 randomly assigned to each study group (CEI-only vs control). Baseline blood pressure was not different between groups (CEI-only, 127 [11]/ 77 [8.7] mm Hg; control, 131 [14]/ 78 [2]). The incidence of hypotension was lower in the CEI-only group than in the control group (5 [20%] vs 15 [60%]; P=.009), with intervention required in 1 (20%) of 5 CEI-only subjects and 7 (47%) of 15 control subjects. Sensory block reached the T10 dermatome in 54.4 (18) minutes in the CEI-only group and 38 (24) minutes in the control group (P=.04). Pain scores and maternal and fetal pulse rates were not different between groups. Analgesic supplementation (250 µg of epidural fentanyl) was used more frequently in the CEI-only group (72% vs 32%; P=.01), without adverse effects.

**Conclusions:** Continuous epidural infusion of 0.2% ropivacaine hydrochloride without bolus administration reduces the incidence of hypotension by 67% and is safer than traditional bolus dosing for routine labor. This method requires further study in high-risk patients, including those with preeclampsia and cardiovascular disease.

Most parturient patients elect to receive epidural anesthesia to ease the physical demands and discomfort of childbirth. However, epidural anesthesia is frequently associated with hypotension, requiring intervention with fluid and/or vasopressors. Furthermore, the fetus may be compromised because uterine blood flow depends on maternal perfusion. Fetal distress can develop rapidly. Epidural dosing strategies that decrease the incidence of maternal hypotension have clear benefits for the mother and fetus.

Epidural anesthesia is routinely administered with bolus dosing of local anesthesia (LA) followed by either continuous epidural infusion (CEI) or repeated bolus doses. Hypotension may occur as a result of anesthesia-induced sympathectomy, usually associated with neuraxial administration of LA. In anticipation of the increase in venous capacitance, preemptive administration of a fluid bolus before LA is delivered. Although this practice is generally safe, hypotension develops in many patients despite the fluid bolus.

Alternative dosing regimens that decrease the incidence and/or extent of the hypotension require development. We hypothesized that CEI of LA, without bolus administration, will result in a lower incidence of hypotension than the bolus dosing method. Patients with uncomplicated term pregnancies who requested epidural anesthesia were studied to determine the incidence of hypotension, the time required for the sensory block to reach the T10 dermatomal level, and the patient’s perception of pain with CEI-only vs CEI with bolus dosing.

**Methods**

After institutional review board approval, 50 subjects with term pregnancies (38–42 weeks’ gestation) who requested epidural anesthesia during labor were enrolled in the study after informed consent. Subjects were excluded if they had pregnancy-induced hypertension (PIH) (preeclampsia), con-
comitant cardiovascular disease, documented coagulation abnormality or abnormal bleeding history, evidence of infection or anatomic abnormality at the proposed catheter insertion site, or if they declined study participation or the epidural anesthesia during labor, were unable to give informed voluntary consent, or were younger than 18 years. Subjects were also excluded from the study in cases of difficult epidural placement, inadvertent epidural puncture (wet tap), precipitous labor, or fetal distress mandating urgent/emergent cesarean delivery. Subjects were randomly assigned to the experimental or control group in a single-blind design. A T10 level of anesthesia was the goal of the dosing regimen.

Each subject received a 750-mL crystalloid bolus intravenously before placement of a lumbar epidural catheter via the loss-of-resistance technique. All catheters were placed 6 cm into the epidural space without a test dose of LA with epinephrine. All subjects received 0.2% ropivacaine hydrochloride delivered by a Baxter APII pump (Baxter, Deerfield, Ill). The control group received bolus administration of epidural anesthesia (10 mL of 0.2% ropivacaine hydrochloride) followed immediately by CEI of 10 mL of 0.2% ropivacaine hydrochloride per hour. subjects assigned to the experimental group received CEI of 0.2% ropivacaine hydrochloride with no bolus.

Maternal blood pressure (BP) and maternal and fetal pulse rates were recorded every 5 minutes for 2 hours. The first measurement was obtained immediately before epidural dosing (baseline) between uterine contractions. Hypotension was prospectively defined as (1) a 20% decrease in systolic BP and/or mean arterial pressure (MAP); and/or (2) systolic BP less than 100 mm Hg.

Discomfort was assessed every 5 minutes using a visual analog scale (VAS), where 1 indicated pain free and 5, severe pain. In cases of moderate to severe pain ratings on two or more successive evaluations after initiation of epidural anesthesia, subjects were given adjunctive fentanyl (250 μg) to ensure patient comfort. The level of epidural anesthesia was evaluated by pin-prick discrimination every 5 minutes. All other aspects of patient care were unchanged.

All data were collected prospectively. The incidence of hypotension was tested using a 2×2 χ² analysis, with a Fisher exact test for categoric variables. A paired, two-tailed t test was used to evaluate differences between groups. Significance was established at an α level of .05. Data are given as mean (SD) unless otherwise indicated.

Results
Fifty subjects completed the study (25 CEI-only and 25 control subjects). No technical complications occurred. There were 1.2 (0.4) epidural placement attempts (needle and/or catheter removed before completion of catheter insertion) in both groups. Subject characteristics were similar in both groups (Table 1).

## Table 1

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>CEI-Only Group† (n=25)</th>
<th>Control Group‡ (n=25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>27.6 (6.2)</td>
<td>27.0 (5.6)</td>
</tr>
<tr>
<td>Height, cm</td>
<td>166 (7)</td>
<td>164 (7)</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>85 (17)</td>
<td>82 (22)</td>
</tr>
<tr>
<td>Gestational age, wk</td>
<td>39.8 (1.1)</td>
<td>39.6 (1.1)</td>
</tr>
<tr>
<td>Gravidà</td>
<td>2.4 (1.5)</td>
<td>2.4 (2.0)</td>
</tr>
<tr>
<td>Para</td>
<td>1.1 (1.2)</td>
<td>0.8 (1.1)</td>
</tr>
<tr>
<td>Cervical dilatation, cm</td>
<td>4.2 (1.2)</td>
<td>4.5 (1.1)</td>
</tr>
<tr>
<td>Hematocrit, %</td>
<td>36 (3)</td>
<td>36 (3)</td>
</tr>
<tr>
<td>Oxytocin infusion, %</td>
<td>84</td>
<td>72</td>
</tr>
</tbody>
</table>

* Data are given as mean (SD).
† Patients who received continuous epidural infusion (CEI) of 0.2% ropivacaine hydrochloride without bolus dosing.
‡ Patients who received CEI of 0.2% ropivacaine hydrochloride with bolus dosing.

The baseline systolic BP was 112 mm Hg and declined to 104 mm Hg in the CEI-only group at 15 minutes, reaching 100 mm Hg by 40 minutes. In the control group, systolic BP declined to 99 mm Hg at 15 minutes. The difference was statistically significant at 15 minutes (P=.03). A significant difference was noted in systolic BP and MAP at 20 minutes (P=.02). The systolic BP readings were significantly lower in 15 (71%) of 21 control subjects between 20 and 120 minutes. At 50 minutes, the mean systolic BP in the CEI-only group declined 3% (4 mm Hg) compared with baseline levels (123 [14]/73 [11] mm Hg) (P=.01), and the control group systolic BP had declined about 11% (117 [13] mm Hg) from baseline levels.

In the CEI-only group, 5 (20%) of 25 subjects became hypotensive compared with 15 (60%) of 25 subjects in the control group. Three subjects had baseline systolic BP readings less than or equal to 110 mm Hg. Of these subjects, 2 in the CEI-only group had a systolic BP measurement of less than 110 mm Hg, meeting criteria for hypotension. The baseline BP readings of 104/69 mm Hg and 110/67 mm Hg declined to 99/69 mm Hg and 99/81 mm Hg, respectively. One subject in the control group had a baseline BP of 103/52 mm Hg but did not fulfill criteria for hypotension. Thus, the incidence of clinically significant hypotension may be as low as 12% for the CEI-only method, representing an 80% decrease compared with the bolus technique.

Treatment for hypotension was administered to 7 of 15 subjects in the control group and to 1 subject in the CEI-only group.
More subjects in the control group had greater and longer-lasting decreases in BP compared with the CEI-only group (Figure 1). One subject in the CEI-only group and 5 in the control group did not receive intervention for hypotension despite marked (≥25% or systolic BP < 100 mm Hg) and/or prolonged (≥10 minutes) BP decreases. If analyzed on an intent-to-treat basis, 40% of the CEI-only group and 80% of the control group would have received treatment (P=.13). It is common practice to administer fluid or ephedrine immediately in obstetric patients who complain of nausea/emas. No patients met criteria for hypotension secondary to symptomatic therapy of nausea/emas.

Maternal pulse rates remained unchanged during the study in both the CEI-only and control groups. Although statistical significance was demonstrated between the two groups at three time intervals, no pattern or clinical significance can be
A statistically significant reduction in VAS score was noted by 5 and 15 minutes in the CEI-only group (CEI-only, 3.9 [1.2]; control, 4.3 [0.88]). Both groups demonstrated progression toward a VAS score of 1. A statistically significant reduction in VAS score was noted by 5 and 15 minutes in the CEI-only (P=.001) and control (P=.02) groups, respectively. However, only the 30-, 35-, and 40-minute VAS scores were different between the two groups.

There was no difference between groups in baseline VAS pain scores (CEI-only, 3.9 [1.2]; control, 4.3 [0.88]). Both groups demonstrated progression toward a VAS score of 1. A statistically significant reduction in VAS score was noted by 5 and 15 minutes in the CEI-only (P=.001) and control (P=.02) groups, respectively. However, only the 30-, 35-, and 40-minute VAS scores were different between the two groups.

Rescue analgesia was provided by epidural administration of 250 μg of fentanyl. This adjuvant analgesia was used more frequently (72% vs 32%) and earlier (17.6 vs 32.5 minutes) in the CEI-only group. Fifty-eight percent of CEI-only subjects received fentanyl within the first 20 minutes. Figure 2 shows the VAS scores at the time of fentanyl administration (baseline) and every 5 minutes for 20 minutes. In the CEI-only group, the VAS decreased from 4.2 (1.0) to 3.2 (1.2) at 5 minutes (P<.001). In the control group, the VAS decreased from 3.7 (1.1) to 2.7 (1.0) (P=.007) 5 minutes after fentanyl was administered. The mean VAS continued to decline over the next 20 minutes to a nadir of 1.6 (0.60) and 1.6 (0.74) for the CEI-only and control groups, respectively. There were no associated changes in maternal BP or fetal pulse rate after fentanyl (Table 2).

One subject from the control group continued to report pain and requested additional analgesia 15 minutes after the first rescue dose, which was given at 40 minutes. She received a second fentanyl dose (250 μg) at 55 minutes and reported relief after receiving a 20-minute infusion of 500 μg of fentanyl. This subject met criteria for hypotension after the second dose of fentanyl, but because she received bolus dosing of LA, it is difficult to conclude what factor(s) contributed to the hypotension. No fetal pulse rate changes were noted, though she did require diphenhydramine hydrochloride for pruritus.

**Comment**

More than half of parturient patients choose to have epidural anesthesia. Typically, dilute LA solutions are administered by bolus dosing of 5 mL to 15 mL followed by CEI. In addition to offering patients pain relief, epidural anesthesia has been shown to speed the first and second stages of labor in nulliparous women and allows obstetricians to perform mid- or low-forceps delivery, vacuum extraction, or cesarean delivery.

Technical complications associated with epidural anesthesia include inadvertent dural puncture and anatomic factors that hinder successful catheter placement (eg, morbid obesity). Increased venous capacitance resulting from the inhibited sympathetic outflow and maternal hypotension are physiologic complications. Because maternal hypotension is so prevalent, proper positioning and prophylactic intravenous fluids before dosing of the epidural catheter are measures that should be taken for all parturient patients. Many patients (60% in our control group) will still become hypotensive and may require treatment with ephedrine or supplemental fluid. The safest method of epidural anesthesia during labor would appear to be placement and initiation of 0.2% ropivacaine hydrochloride infusion without a bolus dose at 3 cm of cervical dilatation. This method would take advantage of the safety features we observed and limit maternal discomfort.

Maternal hypotension requires rapid treatment. Decreased perfusion in brainstem structures results in nausea, vomiting, and syncope, and thus, increased risk of aspiration. Anesthesiologists empirically treat patients for nausea and vomiting with ephedrine, often while determining BP. Difficulties with intubation and aspiration are the leading causes of anesthesia-related mortality in parturient patients.

The decrease in uterine blood flow also places the fetus at great risk. Maternal hypotension may be more deleterious than umbilical cord compression, as it may attenuate fetal compensatory responses. Histologic neuronal damage and fetal cerebral infarction have been associated with the degree of maternal hypotension but not hypoxia. Fetal subendocardial injury is another complication of maternal hypotension.

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**Figure 2.** Visual analog scale (VAS) pain scores after epidural fentanyl (250 μg) in patients receiving continuous epidural infusion (CEI) of 0.2% ropivacaine hydrochloride with (CEI-only group; n=25) and without (control group; n=25) bolus dosing. Each data point represents the mean (SD) score of 18 patients and 8 patients for the CEI and control groups, respectively. *Statistically significant difference (P<.05) compared with the baseline.
High-risk parturient patients with PIH may benefit from the no-bolus CEI dosing method. Pregnancy-induced hypertension is observed in about 8% of pregnant women and is the leading cause of maternal morbidity. Blood pressure control in this population improves both maternal and fetal outcomes.

Inadvertent intrathecal placement must be considered when inserting epidural catheters, including established catheters. Slow administration of ropivacaine via CEI allows greater time to verify correct placement. Furthermore, the isobaric nature of the commercially available 0.2% ropivacaine hydrochloride may limit cephalad spread and provide a margin of safety for inadvertently placed intrathecal catheters.

A variety of LA types and dosing regimens have been used in obstetric anesthesia. Ropivacaine has distinct advantages with respect to patient safety and pharmacologic properties. Although structurally and pharmacodynamically similar to bupivacaine hydrochloride, ropivacaine has greatly reduced cardiotoxic properties compared with bupivacaine. Ropivacaine may produce fewer central neurologic symptoms compared with lidocaine hydrochloride when administered systemically. Ropivacaine has greater effects on sensory fibers than on motor fibers. Obstetric patients can thus be given less concentrated LA solutions so that motor function is preserved while analgesia is sustained. Several variations of bolus dosing regimens have been evaluated but have not been found to reduce the risk of maternal hypotension. Karinen et al. observed that administration of the initial bolus in divided doses rather than in a single large dose did not alter the hemodynamic changes associated with epidural initiation. Variation of the CEI rates of ropivacaine from 2 mL/h to 10 mL/h following bolus dosing did not reduce the need for top-up doses in parturient patients.

The technique used in the current study has several limitations: lack of a test dose, increased time to effectiveness, and increased need for rescue analgesia. A test dose of LA with epinephrine is often used to rule out intravascular and intrathecal catheter placement. This practice is not without risk, however, and an epidural test dose is controversial in obstetric anesthesiology. Also, intravenous administration of epinephrine reduces uterine blood flow, an adverse effect that is of particular importance in patients with PIH.

Another limitation of this method of administration is the longer time to effectiveness of the anesthesia. The time required for the anesthetic level to reach T10 was increased from 38 to 54 minutes. Because our method of rescue analgesia with 250 μg of fentanyl is safe and effective, we believe that the benefit of decreased hypotension outweighs the risk of an additional 16 minutes for the anesthetic level to reach T10 when pain scores are similar.

Subjects in the CEI-only group needed rescue analgesia more often than control subjects. The adjuvant use of fentanyl provides an analgesic therapeutic option for anesthesiologists who use the no-bolus CEI method. Our data show a reduction in VAS from 3.9 to 2.6 during the first 30 minutes in the CEI-only group and no difference in the control group during the same period. Studies have shown that patients may require top-up doses even after the desired anesthetic level is established, perhaps as labor progresses and the S2 to S4 nerves become involved. One final limitation of our study is that physician bias may have influenced fentanyl administration. However, the goal of this study was to evaluate a potentially safer, hemodynamically stable dosing method for parturient patients.

The rescue dose of fentanyl, 250 μg, delivered epidurally, was used prospectively. Epidural fentanyl (75 μg) has been previously reported to have no effect on fetal pulse rate. In contrast, intrathecal fentanyl may result in decreased fetal pulse rate. Most anesthesiologists consider intrathecal administration of opioids to have fivefold to tenfold greater potency. The use of 10 μg to 25 μg of fentanyl intrathecally has been well established in obstetric anesthesia, especially when used in combination with an epidural catheter. A 25-μg intrathecal dose translates into a 250-μg epidural dose.

Pruritus was noted in many patients. However, the inci-
dence, duration, and severity of these symptoms in patients receiving intrathecal fentanyl do not correspond to the dose administered.\textsuperscript{20} It is reasonable to think that the epidural route may produce a similar adverse effect profile.

In summary, alternative epidural dosing strategies may improve the safety of anesthetic care for mother and fetus. We have demonstrated that the incidence of maternal hypotension can be dramatically reduced (67\%) with 0.2\% ropivacaine hydrochloride CEI without bolus dosing. Furthermore, epidural administration of 250 \( \mu \)g of fentanyl provides hemodynamically stable, rapidly effective relief for breakthrough pain. We favor the early placement of epidural catheters in parturient patients who request epidural anesthesia for labor (ideally, at 3 cm of cervical dilatation). This method allows for greater patient comfort and satisfaction while decreasing the issues of onset delay and rescue analgesic use. Further studies will need to be performed to determine the efficacy of this technique in high-risk obstetric populations.

References


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