Effects of a 30-mL Epidural Normal Saline Bolus on Time to Full Motor Recovery in Parturients Who Received Patient-Controlled Epidural Analgesia With 0.125% Bupivacaine With 2 μg/mL of Fentanyl

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Previous research suggests that an epidural bolus of 30 mL of normal saline after vaginal delivery may decrease the time for recovery from motor block. A double-blind, randomized controlled study was conducted in 46 parturients to determine if a 30-mL normal saline bolus or sham administered via epidural approach after delivery reduces the time to full motor recovery and the time to 2-dermatome sensory regression. No significant difference was found in time to full motor recovery (saline group 83.18 ± 54 minutes vs control group 100.23 ± 48 minutes, P = .27) or time to 2-dermatome sensory regression (saline group 29.32 ± 16.35 minutes vs control group 36.14 ± 14.39 minutes, P = .15). Results suggest no advantage to the administration of a saline bolus after delivery to hasten the motor recovery in parturients. A post hoc power analysis suggested a sample size of 204 subjects would have been needed to show a difference for this dilute local anesthetic regimen. There were no complications to the technique, which suggests that it is safe to perform, but the difference in recovery (approximately 17 minutes) from a dilute local anesthetic dose may not be clinically significant.

Keywords: Epidural, motor block, normal saline, parturient, washout.

Euraxial analgesia via epidural or combined spinal-epidural approach is considered the gold standard for pain relief during labor. Use of a dilute local anesthetic combined with an opioid for infusion is a highly accepted technique for epidural analgesia during labor, which is associated with improved maternal outcomes and enhanced maternal satisfaction and sense of control. Factors that affect patient satisfaction with epidural anesthesia include pain relief, enhanced control during labor, and timely regression of motor blockade.

Despite use of dilute local anesthetic/opioid admixtures for vaginal delivery, many patients still experience prolonged motor blockade. Time to full motor recovery after various epidural local anesthetics ranges from 90 to 240 minutes. Prolonged motor blockade in parturients may contribute to decreased patient satisfaction, increased patient anxiety, and extended hospital stays. There is no reversal agent for local anesthetics, and motor function resolves because of the uptake into the circulation and metabolism and the elimination of the medication.

A technique thought to accelerate the return of motor function from epidural anesthesia is injection of crystalloid solutions of either normal saline or lactated Ringer's solution into the epidural space. This "washout" technique is performed before catheter removal. The landmark study completed by Johnson and colleagues in 1990 demonstrated the effects of a 45-mL epidural bolus of crystalloid solution administered to patients following cesarean delivery using 0.75% bupivacaine for epidural anesthesia. The authors reported a significant reduction in the time to motor recovery by more than 100 minutes between the control group (mean ± SD; 178 ± 70 minutes) and the experimental group (70 ± 38 minutes), with no noted differences in duration of sensory anesthesia or postoperative analgesia (P = .001). Several additional investigations using different surgical procedures and patient populations demonstrated a reduction in the time to motor function recovery from a dense surgical block by an average of 30 to 45 minutes.
when a 30-mL normal saline bolus was given through the epidural catheter before removal.6-10

However, limited research has been conducted to evaluate the effects of an epidural saline bolus before epidural catheter removal in patients receiving dilute local anesthetics, such as the concentration for parturients for labor analgesia. Williams et al11 conducted an investigation using an epidural saline bolus following patient-controlled epidural analgesia (PCEA) with 0.125% bupivacaine with 2 μg/mL of fentanyl for vaginal delivery. This study measured motor function recovery at 15-minute intervals up to 60 minutes following the administration of a 30-mL normal saline bolus (experimental group, n = 27) given immediately before removal of the epidural catheter, comparing their recovery time with that of a group of patients who did not receive an epidural normal saline bolus (control group, n = 26). The authors reported that a higher proportion of patients in the experimental group had full motor recovery at the 45-minute time interval compared with the proportion of patients with full motor recovery in the control group (P = .047).11 In the experimental group, 88% had partial or no motor block compared with 65% in the control group. However, investigators did not measure time to full motor recovery. Additionally, the experimental group had a higher baseline sensory dermatome level, which may have biased the results. Subjects and data collectors were also not blinded to group assignment.

Given the limited research to evaluate the efficacy of administering an epidural saline bolus to hasten motor function recovery in the parturient population, the purpose of this investigation was to build off the work of Williams et al11 to determine if the injection of a 30-mL normal saline bolus before epidural catheter removal in patients receiving dilute local anesthetics, such as the concentration for parturients for labor analgesia, may have biased the results. Subjects and data collectors were also not blinded to group assignment.

Materials and Methods
Following institutional review board approval, 46 parturients in active labor with continuous lumbar epidural anesthesia were enrolled in this experimental, prospective, randomized, double-blind investigation. Inclusion criteria included the following: full-term gestation, age greater than 18 years, ASA physical status 1 or 2, able to read and understand directions in English, and singleton pregnancy with anticipated vaginal delivery. Patients were excluded based on the following criteria: scheduled cesarean delivery, identified high-risk pregnancies (pre eclampsia, twins, cardiac anomalies, and/or uncontrolled systemic disease), psychiatric disorders, known neurologic disorder, musculoskeletal disorder, actual or suspected dural puncture, receipt of intrathecal narcotics, combined spinal-epidural blocks, and requirement for additional supplemental epidural analgesia with solutions other than 0.125% bupivacaine with 2 μg/mL of fentanyl before enrollment.

Before enrollment, all subjects had an epidural block placed by a staff anesthesia provider (physician or Certified Registered Nurse Anesthetist), anesthesia resident, or student registered nurse anesthetist. Epidural catheters were placed at the L3-L4 or L4-L5 interspace, using a loss-of-resistance technique with saline or air. All patients were given an initial bolus of 6 to 10 mL of 0.125% bupivacaine with 2 μg/mL of fentanyl, after confirmation of a negative test dose. A continuous epidural infusion of the same solution was initiated with rates ranging from 8 to 10 mL/h. Patients were provided with PCEA-demand boluses ranging from 3 to 5 mL every 10 to 15 minutes with a 4 bolus per hour lockout. Shortly after epidural placement, an initial anesthetic level was assessed to determine if the block was adequate and the epidural anesthesia was functioning properly. After determination of a functioning epidural, patients were then approached for study participation. Patients labored through the first stage of labor to full dilatation of the cervix. Patients requesting supplemental analgesia during labor were given an additional bolus of local anesthetic from our standardized laboring epidural solution of 0.125% bupivacaine with fentanyl, 2 μg/mL. Any participant requiring initial or supplemental epidural boluses for increased pain with solutions other than our standard solution of 0.125% bupivacaine and fentanyl (2 μg/mL) before enrollment were excluded from the study.

After informed consent, participants were randomly assigned to 1 of 2 groups determined by a random numbers table. The saline group received an epidural injection of 30 mL of normal saline (divided into three 10-mL sterile syringes). The control group received a simulated 30-mL normal saline injection before epidural catheter removal. Patients were not told their group assignment; however, we cannot rule out that subjects in the saline group did not feel the saline being injected. Following delivery of the baby, placenta, and any necessary perineum repair, a study investigator blinded to group assignment performed a baseline motor and sensory assessment. Bilateral motor function was determined by the modified Bromage scale (grade 4, complete motor block; grade 3, hips and knees blocked with intact ankle flexion; grade 2, hips blocked with intact knee and ankle flexion; grade 1, block resolution, hip, knee, and ankle flexion).11 Bilateral dermatome sensory levels were assessed using a “cold test” with ice placed in an examination glove, to determine the highest sensory dermatome level.11 A staff anesthesia provider not participating in data collection then entered the participant’s room with a sealed envelope (designating group assignment), a towel, and three
10-mL syringes of preservative-free normal saline. Study personnel and nursing staff were requested to leave the room and the epidural infusion pump was stopped. The staff anesthesia provider was instructed by study staff ahead of time to open the envelope and without revealing assignment to the participant, to administer the 30-mL epidural saline bolus via the catheter (saline group) or slowly inject (over 2 minutes) the normal saline into the towel (control group). The provider then removed the epidural catheter per protocol. The subjects were all positioned at a 30- to 40-degree angle. The degrees of motor and sensory blocks were evaluated by the same blinded study investigator every 15 minutes until complete return of motor function. Sensory data were collected until return of full motor function allowing for determination of 2-dermatome sensory regression.

Additional data were collected at the same time interval to include pain scores as measured by the verbal numeric rating scale (scale of 0-10, with 0 indicating no pain and 10 being the worst pain imaginable) and vital signs (blood pressure, heart rate, and respiratory rate). After return of full motor function, patients were asked to complete a survey in Likert-scale format to assess their overall satisfaction with postdelivery rate of recovery of motor and sensory function (1 indicated totally dissatisfied; 2, somewhat dissatisfied; 3, satisfied; 4, somewhat satisfied; and 5, totally satisfied). The data collection instruments used in this study are the same as those used in the study by Williams et al11 (ie, modified Bromage scale, measurement of bilateral dermatome sensory levels with the “cold test,” verbal numeric rating scale to measure pain, and Likert scale to assess patient satisfaction).

Given the lack of data evaluating the return of motor function following an epidural saline using a concentration of 0.125% bupivacaine and 2 μg/mL of fentanyl, our power analysis was based on the study by Johnson et al.6 Their study demonstrated a reduction in the time to full motor recovery with an epidural infusion of 0.75% bupivacaine from 178 ± 70 minutes to 70 ± 38 minutes following an epidural normal saline bolus.6 In the current investigation, it was anticipated that due to the decreased local anesthetic concentration in comparison to the study by Johnson et al,6 the reduction in time to full motor recovery would be less pronounced than previously published data. It was hypothesized that patients in the saline group would have a mean time to full motor recovery of approximately 124.2 ± 54 minutes compared with the control group of 178.0 ± 70 minutes. Based on this mean difference, the calculated effect size was 0.86. Using this large effect size, based on an α of .05 and a β of .2, it was determined that 23 subjects would be required in each group to achieve statistical significance. This computation therefore assumed that the mean difference was 53.8 minutes (95% confidence interval, 16.06-91.54 minutes).

Descriptive and inferential statistics were used to analyze the results. Continuous outcomes were compared with independent t tests for parametric data and the Mann-Whitney U test or Wilcoxon-rank sum test for nonparametric data as appropriate. Categorical data were compared using Pearson χ² or Fisher exact tests as appropriate. A Kaplan-Meier survival analysis using the log-rank test was performed to compare the rates until time of complete motor recovery. Continuous outcomes are presented as the mean ± standard deviation. P values less than .05 were considered significant.

Results

A total of 44 subjects were available for data analysis, with 22 subjects in the experimental group and 22 subjects in the control group. Two subjects were excluded from final data analysis (1 required emergency cesarean delivery; and 1 had the epidural pump inadvertently turned off). Therefore, we did not achieve our estimated sample size of 23 subjects per group. No differences were noted in baseline demographics, total analgesic requirements, duration of infusion, number of anesthesia-administered boluses, or time from last bolus to delivery (P > .05; Table 1). Median initial sensory dermatome level was T10 in the saline group and T9 in the control group (P = .75). Initial motor function was the same in both groups (median Bromage score, 2—hips blocked with intact knee and ankle flexion; P = .94). Median pain scores at the time of full motor function recovery were zero, with no differences noted between groups (P = .28). One subject experienced postpartum hemorrhage as a complication of delivery, but it did not affect study participation. No other adverse events were noted in either group.

On average, the saline group was noted to have a decreased time to full motor recovery compared with the control group, 83.18 ± 54 minutes vs 100.23 ± 48 minutes, respectively; however, this difference was not statistically significant (t = 1.112, df = 42, P = .27, Figure 1). Kaplan-Meier survival analysis revealed no difference in time to full motor recovery survival curves between the 2 groups (χ² = 0.51, df = 1, P = .48; Figure 2). We examined median degree of motor block at 15-minute intervals and found no significant differences between the groups (P > .05; Table 2). At 45 minutes, 9 subjects in the saline group and 3 in the control group had full motor recovery (41% vs 14%, P > .05). The mean time to 2-dermatome sensory regression was 29.32 ± 16.35 minutes for the saline group and 36.14 ± 14.39 minutes for the control group (t = 1.47, df = 42, P = .15, Figure 3).

Satisfaction scores were similar; the saline group had a median score of 5 (range, 3-5), and the control group had a median score of 4.5 (range, 4-5; P = .17). No participants in the present study complained of acute lower back pain, nuchal pain, headaches, or vision deficits during or after the 30-mL normal saline epidural bolus injection.
Discussion
The results of this study demonstrated, on average, a 17-minute reduction in the time to full motor function recovery and a 7-minute reduction in time to 2-dermatome sensory regression in participants receiving a 30-mL normal saline epidural bolus compared with control participants. However, these differences were not statistically significant. Our findings are consistent with those of Williams et al., who found a tendency toward less motor blockade in parturients administered a 30-mL saline bolus after vaginal delivery with use of a dilute local anesthetic solution (0.125% bupivacaine with fentanyl, 2 μg/mL). Additionally, in our study, immediately before the saline bolus (sham treatment) only 4 participants (9.1%) had complete loss of motor function, whereas 27 (61.4%) of the participants had only partial or no loss of motor function. Given that most participants had minimal to no loss of motor function at baseline may explain the lack of a clinically or statistically significant effect with the 30-mL saline bolus we used. Thus, our study may have been underpowered to detect this small of a difference. We conducted a post hoc analysis to assess the potential impact of participant characteristics on the results.

Table 1. Demographic and Independent Variables
Abbreviations: CLE = continuous lumbar epidural analgesia; LA = local anesthetic.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Saline (n = 22)</th>
<th>Control (n = 22)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y (mean ± SD)</td>
<td>25.14 ± 4.03</td>
<td>25.55 ± 4.34</td>
<td>.38</td>
</tr>
<tr>
<td>Height, cm (mean ± SD)</td>
<td>163.14 ± 8.48</td>
<td>163.24 ± 6.12</td>
<td>.48</td>
</tr>
<tr>
<td>Weight, kg (mean ± SD)</td>
<td>79.66 ± 13.47</td>
<td>78.28 ± 9.83</td>
<td>.35</td>
</tr>
<tr>
<td>BMI, kg/m² (Mean ± SD)</td>
<td>29.97 ± 3.87</td>
<td>29.53 ± 4.19</td>
<td>.36</td>
</tr>
<tr>
<td>Gravida (range)</td>
<td>1-5</td>
<td>1-6</td>
<td>.06</td>
</tr>
<tr>
<td>Parity (range)</td>
<td>0-1</td>
<td>0-5</td>
<td>.28</td>
</tr>
<tr>
<td>Race or ethnicity (No.)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>13</td>
<td>12</td>
<td>.45</td>
</tr>
<tr>
<td>African American</td>
<td>3</td>
<td>5</td>
<td></td>
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<td>5</td>
<td>0</td>
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<td>Asian</td>
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<td>1</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>2</td>
<td>4</td>
<td></td>
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<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Total volume LA administered (mean ± SD)</td>
<td>92.81 ± 45.93</td>
<td>94.95 ± 52.41</td>
<td>.35</td>
</tr>
<tr>
<td>Total bupivacaine, mg (mean ± SD)</td>
<td>116.26 ± 5753</td>
<td>120.25 ± 66.62</td>
<td>.38</td>
</tr>
<tr>
<td>Total duration of CLE, min (mean ± SD)</td>
<td>433.57 ± 202.94</td>
<td>444.64 ± 205.01</td>
<td>.50</td>
</tr>
<tr>
<td>Time since last bolus, min (mean ± SD)</td>
<td>38.33 ± 104.61</td>
<td>33.23 ± 105.62</td>
<td>.49</td>
</tr>
<tr>
<td>Anesthesia administered top-ups (mean ± SD)</td>
<td>0.14 ± 0.36</td>
<td>0.18 ± 0.5</td>
<td>.48</td>
</tr>
</tbody>
</table>

Table 1. Demographic and Independent Variables
Abbreviations: CLE = continuous lumbar epidural analgesia; LA = local anesthetic.

Figure 1. Comparison of Time to Full Motor Block Recovery of Saline and Control Groups

Results are presented as mean ± SD.
power analysis, which revealed our effect size to be 0.35 with a power of 0.31. To achieve a power of 0.8 based on this effect size, the required sample would be 102 participants per group with a total sample size of 204. Therefore, we cannot draw any definitive conclusions about the efficacy of this intervention on decreasing the time to full motor recovery in this population.

Our results differ from previous investigations, which may be attributed to the concentration of local anesthetics used. Johnson et al. demonstrated that normal saline boluses significantly hastened motor function recovery and sensory regression in patients undergoing cesarean delivery and receiving 0.75% bupivacaine, noting that a mean full motor recovery time was 54 minutes faster in the saline group. Similar findings were noted by Sitzman et al. using 2% lidocaine with epinephrine for patients undergoing elective gynecologic and obstetric surgeries, and by Katircioglu et al. using 2% prilocaine in epidural anesthesia for male patients scheduled for outpatient surgery. Both these studies demonstrated significant improvements in recovery times of motor and sensory blockades. In the current study, the mean time to full motor recovery was 17 minutes faster in the saline group. A difference of 17 minutes in time to full motor recovery may not be clinically significant in patients with minimal to moderate degree of motor blockade, especially when one considers that this intervention would require an anesthesia provider to administer the 30-mL saline bolus shortly after delivery. In a busy obstetric anesthesia practice, the increased workload required may not be feasible. However, given the previous research findings, it is possible that a saline bolus is more efficacious when patients have a significant motor block secondary to administration of concentrated local anesthetics, such as those undergoing cesarean delivery with 2% lidocaine with epinephrine.

Although the mechanism of an epidural normal saline washout to reduce the time of motor and sensory block recovery remains unknown, there are 2 proposed theories. Diluting the local anesthetic in the epidural space is thought to promote the uptake, metabolism, and clearance. It is proposed that a crystalloid bolus in the epidural space increases both secretion and clearance of cerebrospinal fluid from the subarachnoid space, causing a caudal and cephalad spread of local anesthetic that results in a larger surface area for uptake by the vascular and lymphatic system. Clinically, it may be that higher concentrations of local anesthetic equates to increasing amounts of unbound drug that can be diluted with the bolus of epidural normal saline, thereby making the local anesthetics less likely to continue to contribute to a potential nerve blockade. Conversely, lower concentrations of local anesthetic in the epidural space equates to lower amounts of drug to “wash out,” making the effect less appreciable.

A second theory involves the idea of ion “trapping.” Local anesthetics are weak bases with pKa values slightly above physiologic pH (7.4). Because of this physiochemical property, less than 50% of the local anesthetic solution exists in the nonionized form, because only the uncharged, lipid-soluble form diffuses across the spinal meninges to the site of action in the subarachnoid space. It is proposed that injecting normal saline (a slightly acidic solution with a pH of 5.0) into the epidural space decreases the pH, resulting in a shift of the local anes-

Table 2. Median Sensory Dermatome Level

<table>
<thead>
<tr>
<th>Time, min</th>
<th>Saline (n = 22)</th>
<th>Control (n = 22)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>T10</td>
<td>T9</td>
<td>.75</td>
</tr>
<tr>
<td>15</td>
<td>T10</td>
<td>T11</td>
<td>&gt; .99</td>
</tr>
<tr>
<td>30</td>
<td>T12</td>
<td>T12</td>
<td>.84</td>
</tr>
<tr>
<td>45</td>
<td>L1</td>
<td>L1</td>
<td>.92</td>
</tr>
<tr>
<td>60</td>
<td>L1</td>
<td>L2</td>
<td>.67</td>
</tr>
</tbody>
</table>

Figure 2. Survival Analysis of Time to Full Motor Recovery
Kaplan-Meier survival analysis revealed no difference in time to full motor recovery survival curves between the 2 groups ($\chi^2 = 0.51$, df = 1, $P = .48$).

Abbreviations: CI, confidence interval; HR, hazard ratio.
thetic from the nonionized form to the ionized form. The ionized form of the local anesthetic is unable to diffuse across the meninges to exert its effects and is therefore unable to cross to the site of action.

The concern with use of a saline washout is the possible occurrence of increased systemic absorption leading to central nervous system local anesthetic toxicity. However, Johnson et al6 and Chan et al7 showed that small volumes of epidural saline washouts up to 40 mL did not result in detectable bupivacaine or lidocaine plasma concentrations. Another concern is that a saline washout could cause patients to experience pain sooner after vaginal delivery. However, we found no differences in pain scores at the time of full motor recovery between the 2 groups, which is consistent with the findings of Williams et al.11

The volume of the normal saline bolus chosen for this study was related to its clinical efficacy and safety profile based on previous research studies. Rodriguez et al8 did not recommend washouts with high volumes of crystalloid solutions because of unwanted side effects. The complications associated with high volumes of crystalloid solutions included transient increases in epidural pressures and subarachnoid pressures.8 Increased epidural pressure can manifest as signs and symptoms of acute low back pain, paraspinal muscle spasm, lower extremity radicular pain, nuchal pain, headache, and temporary visual deficits. Previous studies using an epidural washout have confirmed the safety of the technique.6-10 No participants in the present study complained of acute lower back pain, nuchal pain, headaches, or vision deficits during or after the 30-mL normal saline epidural bolus injection. Additionally, there was no progression of sensory dermatome blockade above the initial level assessed.

Given the results of this investigation, it appears that the injection of 30 mL of normal saline into the epidural space on completion of an epidural infusion of 0.125% bupivacaine with fentanyl (2 μg/mL) before epidural catheter removal in parturients is safe. Although the saline group did recover motor function 17 minutes faster, this difference was not statistically significant. Given that our study may be underpowered, we cannot draw any definitive conclusions on the efficacy of this intervention. Furthermore, we do not believe this technique may be feasible in a busy obstetric practice in parturients receiving a dilute local anesthetic concentration because it would increase anesthesia provider workload. Based on previous research findings,6-10 a normal saline washout may be more efficacious after administration of concentrated local anesthetics, such as those used during cesarean deliveries.

REFERENCES


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