A normal saline bolus administered before discontinuation of the epidural catheter reportedly hastens return of motor function following epidural anesthesia. However, this technique has not been investigated in parturients following vaginal delivery.

In this randomized, prospective pilot study, all enrolled parturients received 0.125% bupivacaine and 2 μg/mL of fentanyl by continuous infusion. After delivery, the experimental group received a 30-mL normal saline bolus through the epidural catheter; the control group did not. Sensory and motor function was evaluated at baseline and every 15 minutes for 60 minutes. Groups were compared using Mann-Whitney U.

Fifty-three subjects were included (experimental: n = 27; control: n = 26). Median sensory dermatome levels were significantly different at baseline (experimental: T8, control: T10, P = .01), but not at any other time point. The experimental group had less motor blockade than the control group at every time point; however, the difference was statistically significant only at the 45-minute measure (P = .047).

Although the experimental group exhibited a tendency to less motor blockade, the baseline difference in sensory dermatome levels made it difficult to draw definitive conclusions about the efficacy of a saline bolus in this parturient population. Future research is needed to confirm these results.

**Keywords:** Epidural analgesia, motor, obstetrics, saline injection, sensory dermatome.

Continuous lumbar epidural analgesia has been shown to be one of the most effective modalities for pain relief during labor and delivery. Continuous lumbar epidural analgesia has minimal impact on both maternal and fetal physiology and can be easily titrated to meet the increasing demands during labor. Additionally, if cesarean delivery is required, a concentrated local anesthetic can be administered to achieve surgical anesthesia. Despite these advantages, prolonged postoperative sensory and motor blockade often result, contributing to unnecessary patient anxiety and extended recovery. This prolonged recovery may lead to increased hospital costs, decreased patient satisfaction, and delayed time to maternal-neonatal bonding.

The current standard of care for parturients who have received epidural analgesia is to allow the effects of the local anesthetics and opioids to diminish over time, a period that may last as long as 2 to 4 hours. Therefore, this has prompted interest in the investigation of techniques to safely hasten the return of motor and sensory function in this population.

One technique that has been investigated as a potential means to hasten return motor function is administration of a bolus of crystalloid solution into the epidural space prior to removal of the epidural catheter. Johnson et al demonstrated that a 45-mL bolus of 0.9% normal saline (NS) or lactated Ringer's solution significantly shortened the duration of motor blockade (70 minutes vs 178 minutes) in a group of patients undergoing cesarean delivery who received lumbar epidurals with 0.75% bupivacaine. However, they noted no differences in sensory dermatome regression compared with a control group (P < .05). Similar findings were also reported by Sitzman et al, in which they studied the effects of administering 30 mL of NS in groups of patients who received epidural anesthesia with 2% lidocaine and 1:200,000 epinephrine. Although similar results were yielded from these studies, it must be noted that these investigations were performed on groups of surgical patients, not laboring parturients, and the groups received different local anesthetic agents, bupivacaine and lidocaine, respectively. Moreover, the 0.75% concentration of bupivacaine is no longer recommended in obstetrical epidural analgesia because of potential cardiotoxicity.

These studies demonstrated the efficacy of a crystalloid solution bolus on promoting an earlier return
of motor function in patients who received a concentrated local anesthetic solution for surgical anesthesia. However, no studies to date, of which we are aware, have evaluated whether similar results could be obtained in groups of labor and delivery patients receiving epidural analgesia with a dilute concentration of local anesthetic and opioid solution. Therefore, the purpose of this study was to determine if injecting 30 mL of normal saline (NS) through the epidural catheter after vaginal delivery would hasten the return of sensory and motor function in a group of parturients who received an epidural infusion of 0.125% bupivacaine with 2 μg/mL of fentanyl for labor analgesia. Our primary hypothesis was that the degree of motor block would be significantly less in parturients who received a NS bolus compared with a control group. The secondary hypothesis was that sensory dermatome levels would be significantly less in those who received a NS bolus.

**Methods**

After approval by the institutional review board, this randomized, prospective pilot study was performed on 60 parturients. All subjects received a solution of 0.125% bupivacaine with 2 μg/mL fentanyl via patient-controlled epidural analgesia (PCEA) for labor. Inclusion criteria included age greater than 18 years, ASA I or II physical status, ability to read and understand the informed consent, functioning epidural, and planned vaginal delivery. Patients were excluded from participation if they were scheduled for a cesarean delivery, identified as a high-risk pregnancy (preeclampsia, eclampsia, cardiac anomalies, and/or uncontrolled systemic diseases), or had a history of psychiatric, neuromuscular, or neurologic disorders. Demographic data collected included age, height, weight, body mass index, gravidity and parity, ASA physical status, and race or ethnicity.

Prior to recruitment, all subjects had continuous lumbar epidurals via PCEA placed by a staff anesthesia provider, student registered nurse anesthetist, or anesthesia resident. All epidurals were placed in the sitting position using a 17-gauge Tuohy needle at the L2-L3, L3-L4, or L4-L5 interspace with a loss-of-resistance technique with saline or air. Once the epidural space was entered, an epidural catheter was placed 3 to 5 cm into the epidural space, the epidural needle was removed, and the catheter was secured and tested using conventional techniques. A total of 3 to 10 mL of 0.125% bupivacaine with 2 μg/mL fentanyl was then administered in divided doses as a bolus dose, and a PCEA using the same solution as the bolus solution was begun. The PCEA settings were left to the discretion of the individual anesthesia provider but were typically set at a basal rate of 3 to 12 mL/h with a 10- to 30-minute lockout for initiation of a 3- to 5-mL PCEA on-demand bolus. Supplemental local anesthesia was provided as required, and local anesthetic solutions used for supplemental boluses were left to the discretion of the anesthesia provider. Total hourly local anesthetic requirements and type of local anesthesia and opioids administered were recorded on the anesthesia record and data collection sheet.

After informed consent, subjects were randomly assigned using a random numbers table into 1 of 2 groups. Subjects assigned to group 1 (experimental, or NS, group) received a NS bolus of 30 mL administered immediately following delivery, whereas those assigned to group 2 (controls) simply had the epidural catheter removed following delivery. Laboring data included maternal and fetal heart rate patterns, maternal blood pressures, total volume of local anesthesia/opioid administered via the PCEA, the number and type of local anesthetic used for anesthesia-administered boluses, the time in minutes from the last epidural bolus administered (by the anesthesia practitioner) until delivery, and the total time that the epidural PCEA was in place. All subjects’ neuraxial block characteristics included the level of sensory block to cold and extent of motor block using a modified Bromage score. With this score, 0 indicated no motor block; 1, inability to raise an extended leg; 2, inability to flex the knee or raise an extended leg; and 3, inability to flex ankles, flex the knee, or raise an extended leg. The motor block score and sensory block level were measured at baseline (prior to administration of the NS bolus or removal of the epidural catheter) and every 15 minutes for the first hour following analgesia initiation and immediately following discontinuance of the epidural infusion after delivery.

Our primary outcome was the difference in motor block between the 2 groups, and our secondary outcome was to determine if there was a difference in sensory dermatome levels between the 2 groups, respectively. Pain levels were also assessed at the same time intervals using an 11-point verbal numeric rating scale, in which a score of 0 indicated “no pain” and a score of “10” indicated the “worst pain imaginable.” In addition, all subjects were asked to rate their overall satisfaction with the speed of recovery following cessation of their epidural analgesia using a 5-point Likert satisfaction scale, in which 1 indicated completely dissatisfied; 2, dissatisfied; 3, satisfied; 4, very satisfied; and 5, completely satisfied.

A review of the literature revealed no studies that have evaluated differences in the degree of motor block in subjects administered a 30-mL NS epidural bolus after vaginal delivery using 0.125% bupivacaine with fentanyl (2 μg/mL). Most studies have evaluated the mean difference in time to full motor recovery after a NS epidural bolus; however, because of logistical constraints we believed it would not be feasible at our facility to evaluate time to full motor recovery. Therefore, we chose to base the power analysis on the study by Johnson et al, who indicated that time to resolution of motor blockade fol-
 Following 0.75% bupivacaine infusion was decreased from 178 ± 70 minutes to 70 ± 38 minutes following bolus of normal saline solution. Accounting for the decreased local anesthetic solution used in this study, it was anticipated that a similar trend in reduction of motor blockade would be seen. It was hypothesized that spontaneous recovery in the control group would be 50% longer compared with the saline group (30 ± 21 minutes vs 15 ± 9 minutes). Using an \( \alpha \) of 0.05 and a \( \beta \) of 0.20, it was determined that 25 subjects would be needed in each group to achieve statistical significance. Factoring in an attrition rate of 20%, this increased the sample size to 30 subjects per group.

Descriptive and inferential statistics were used to analyze the results. Continuous outcomes were compared with independent \( t \) tests (normal distribution) or the Mann-Whitney \( U \) test (nonnormal distribution) for ordinal data. Categorical data were compared using Pearson \( \chi^2 \) or Fisher exact tests as appropriate. A \( P \) value less than .05 was considered significant.

### Results

- **Sample.** A total of 60 patients were enrolled, but 7 subjects were excluded (4 required cesarean delivery, 2 required extensive blockade for dysfunctional labor, and 1 required immediate postoperative surgical intervention for postpartum hemorrhage), leaving a total of 53 subjects for final analysis. The experimental (NS) group had 27 patients, and the control group had 26. The 2 subjects excluded for dysfunctional labor (1 from each group) received large amounts of local anesthetic and, upon analysis, were found to be extreme outliers. No significant differences in demographics, total analgesic requirements, duration of infusion, type and concentration of local anesthetic used for anesthesia-administered boluses, number of anesthesia-administered boluses, or time from last bolus to delivery were noted between the groups (\( P > .05 \); Table). No significant differences between groups were noted in vital signs, heart rate and blood pressure, or pain scores at any time point (\( P > .05 \)). Pain scores were less than 1 at every time point in both groups. There were no study-related adverse patient outcomes.

- **Sensory Scores.** Sensory scores were compared between groups at each time point (0, 15, 30, 45, and 60 minutes) using the Mann-Whitney \( U \). Despite random assignment, the groups had statistically significantly different sensory scores at baseline. In the NS group, there was a median dermatome level of T8 compared with a median of T10 in the control group (\( P = .01 \)). There was no significant differences between the groups in sensory dermatome levels at any other time point (\( P > .05 \)).

### Table. Demographic and Independent Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Experimental ( (n = 27)^a )</th>
<th>Control ( (n = 26)^b )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y, mean ± SD)</td>
<td>25.0 ± 5.26</td>
<td>26.65 ± 4.06</td>
</tr>
<tr>
<td>Height (in, mean ± SD)</td>
<td>64.63 ± 1.78</td>
<td>64.12 ± 2.44</td>
</tr>
<tr>
<td>Weight (kg, mean ± SD)</td>
<td>82.18 ± 14.19</td>
<td>79.04 ± 12.35</td>
</tr>
<tr>
<td>BMI (kg/m2, mean ± SD)</td>
<td>30.3 ± 4.19</td>
<td>29.77 ± 4.52</td>
</tr>
<tr>
<td>Gravida (median, range)</td>
<td>2 (1-6)</td>
<td>2 (1-6)</td>
</tr>
<tr>
<td>Parity (median, range)</td>
<td>0 (0-3)</td>
<td>0 (0-2)</td>
</tr>
<tr>
<td>Race (No., %)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>16 (59.3)</td>
<td>15 (57.7)</td>
</tr>
<tr>
<td>African American</td>
<td>4 (14.8)</td>
<td>1 (3.8)</td>
</tr>
<tr>
<td>Asian</td>
<td>3 (11.1)</td>
<td>3 (11.5)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>3 (11.1)</td>
<td>6 (23.1)</td>
</tr>
<tr>
<td>Pacific Islander</td>
<td>1 (3.7)</td>
<td>1 (3.8)</td>
</tr>
<tr>
<td>Total volume LA administered (mean ± SD)</td>
<td>88.43 ± 38.61</td>
<td>83.74 ± 42.82</td>
</tr>
<tr>
<td>Total bupivacaine (mg, mean ± SD)</td>
<td>123.37 ± 50.44</td>
<td>109.08 ± 47.82</td>
</tr>
<tr>
<td>Total duration of CLE (min, mean ± SD)</td>
<td>445.56 ± 181.85</td>
<td>461.34 ± 215.29</td>
</tr>
<tr>
<td>Time since last bolus (min, mean ± SD)</td>
<td>312.70 ± 203.6</td>
<td>368.46 ± 199.97</td>
</tr>
<tr>
<td>Anesthesia administered top-ups(^b) (mean ± SD)</td>
<td>0.59 ± 0.69</td>
<td>0.39 ± 0.75</td>
</tr>
</tbody>
</table>

\(^a\) All group-wise comparisons nonsignificant at \( P > .05 \).

\(^b\) Top-ups were the mean number of local anesthetic boluses administered by an anesthesia provider.

Abbreviations: BMI, body mass index; LA, lumbar anesthetic; CLE, continuous lumbar epidural.
60 minutes the median scores had moved within 1 dermatome of each other (treatment, T11, vs control, T12; Figure 1). Groups were also compared by Mann-Whitney U on the overall number of dermatomes improved in the hour from baseline to 60-minute assessment. The treatment group improved by a median of 3.0 dermatomes, whereas the control group improved by only a median of 1.0 dermatome ($P = .006$).

**Motor Scores.** Motor scores were compared between groups at each time point (0, 15, 30, 45, and 60 minutes) using the Mann-Whitney U. Although the treatment group had better motor recovery at all points, there were no statistically significant differences between the groups in the median degree of motor block at baseline, 15 minutes, or 30 minutes (Figure 2). However there was a statistically significant difference at 45 minutes, with subjects in the NS group demonstrating significantly less motor blockade compared with the control group ($P = .047$; Figure 2). By 60 minutes, although the treatment group still demonstrated better recovery, the statistical significance of the difference had disappeared ($P = .062$; Figure 2). Groups were also compared by Mann-Whitney U on the overall number of levels improved in the hour from baseline to 60-minute assessment. The treatment group improved by a median of 0.4 rank, whereas the control group improved by a median of only 0.25 rank levels. The difference, however, was not statistically significant ($P = .416$).

Patient satisfaction scores were similar between the groups, with 85% of subjects in the NS group reporting satisfaction or complete satisfaction with postdelivery recovery of sensory and motor function, compared with 73% ratio in the control group ($\chi^2 = 1.18; P = .29$).

**Discussion**

Expeditious recovery from epidural analgesia in the par-
matone levels, we cannot confirm our hypotheses that a saline bolus hastens motor and sensory recovery in a parturient population. Therefore, the results of this pilot study should be considered preliminary, and further research should be conducted to evaluate time to full motor recovery after a 30-mL NS bolus in this study population.

After vaginal delivery the most important clinical finding is the difference in degree of motor block, because the sooner parturients can regain motor strength, the sooner they can meet the discharge criteria for the labor and delivery unit. Although we did not measure time from bolus to discharge from the labor and delivery unit, we did receive anecdotal reports from the nursing staff that subjects in the experimental group appeared to have faster motor recovery and could be assisted up to a wheelchair and transferred to the postpartum unit sooner than subjects in the control group. Based on this finding, future studies should evaluate time to readiness to discharge, as this may be a clinically significant outcome.

Exactly how crystalloid injections hasten return of sensory and motor function after epidural analgesia remains inconclusive. A proposed mechanism of action is that injection of crystalloid solution into the epidural space results in dilution of local anesthetics and decreases the concentration of drug available for binding at neuronal action sites. Other theories suggest that crystalloid solutions may alter the pH and enhance removal of local anesthetics from neural tissue, or may increase cerebrospinal fluid secretion and clearance, leading to increased clearance of local anesthetic from the subarachnoid space.

Overall recovery profiles indicated a trend toward faster motor recovery with crystalloid bolus into the epidural space among all studies in the literature review. This study differed from previous studies in that it is the first to evaluate the effect of a 30-mL saline bolus after a laboring PCEA was administered to parturients with a dilute local anesthetic/opioid solution. Similar studies using higher local anesthetic epidural concentrations (ie, 0.75% bupivacaine or 2% lidocaine) for surgical analgesia found similar results. Although patient populations and methods differed in the studies, all authors found that an epidural saline bolus hastened recovery from motor blockade alone or both motor and sensory blockade. Additionally, no adverse outcomes related to epidural saline bolus were noted in the review of literature or in this current study.

It is speculated that the rate of resolution of epidural blockade is volume dependent, but the optimal time and amount for injection is unclear. Johnson et al delivered a 45-mL epidural bolus to each of the treatment groups (NS or lactated Ringer’s solution) but did so in 15-mL aliquots separated by 15 minutes. They found that the 45-mL bolus hastened the resolution of motor but not sensory blockade after 0.75% bupivacaine for cesarean delivery (mean, 70-84 minutes vs 178 minutes in control group). Sitzman et al studied the effects of 2 postoperative boluses of 15 mL of epidural saline separated by 30 minutes (total, 30 mL) after administration of 2% lidocaine with 1:200,000 epinephrine for obstetrical and gynecologic surgery. They found that 2 boluses, compared with no epidural saline bolus as a control, significantly reduced the time to full motor recovery (108 ± 9 minutes vs 153 ± 14 minutes, respectively) and sensory recovery (153 ± 9 minutes vs 195 ± 14 minutes).

Chan et al conducted a dose-response study evaluating 6 volunteers’ sensory and motor recovery with 3 different saline volumes. Each subject received plain 2% lidocaine followed 30 minutes later by a 1-mL, 20-mL, or 40-mL NS bolus. They found that subjects who received the 40-mL NS bolus had significantly faster recovery of sensory and motor function compared with the 20-mL and 1-mL groups. These results suggest that a higher volume may hasten recovery of motor and sensory function.

Sitzman et al and Park et al all reported significantly faster time to full sensory and motor block recovery after crystalloid injection; however, Johnson et al did not find a difference in sensory block recovery. The difference between these studies may be attributable to differences in study methods and local anesthetics. Despite variability in local anesthetic concentration, bolus volume and time of administration, and sensory block recovery findings, the higher volume groups in all studies recovered motor function faster. Future studies should investigate if the volume amount of epidural saline administered affects the rate of motor function recovery after use of dilute local anesthetics for vaginal delivery.

Despite the relatively homogenous subject population and standard infusion solution, the lack of control of PCEA infusion rates, and type and concentration or volume of local anesthetic administered for boluses is a limitation of this study. Nonetheless, the groups were similar with regard to volume, type and concentration, and number of boluses administered by anesthesia providers. Investigators should consider tracking the number of PCEA injections made by the subject, and control for the type and concentration of local anesthetic used for anesthesia-administered boluses. However, this may be difficult to implement given the variability in pain experienced by parturients; for example, parturients with fetal malposition (ie, occiput posterior) may require higher concentration of local anesthetics to achieve adequate analgesia. This lack of control may have contributed to the baseline difference in sensory dermatome levels between the groups and thus may have affected the
results of the sensory and motor block recovery.

An additional limitation of this study is that the subjects, nurses, and investigators were not blinded to treatment group. However, evaluation of sensory and motor block was standardized, and only investigators on this study evaluated subjects. Future studies should blind the investigator to the treatment group and explore the option of blinding patients with a sham bolus.

Finally, time to full motor recovery was not evaluated, and as can be seen in Figure 2, several subjects, especially in the control group, had a significant degree of motor block remaining at 60 minutes. Unfortunately, because of logistical constraints we could not evaluate time to full motor recovery. Future research should seek to determine time to full motor recovery and consider using objective measures of motor block recovery as well as time to first spontaneous urination, since autonomic bladder control is one of the last responses to recover after epidural anesthesia. The findings and limitations from this pilot study are currently being used by our group to develop a future study in the same parturient population.

Conclusion
These preliminary pilot results suggest that epidural administration of 30 mL of normal saline immediately after discontinuance of a dilute concentration of local anesthetic infusion may accelerate recovery of motor function in parturients, although not as dramatically as with a higher concentration of local anesthetics. However, given the baseline differences between groups, further research is needed before administration of a saline bolus can be recommended after vaginal delivery with a labor epidural. If faster motor recovery is confirmed by future research, this technique could be incorporated into clinical practice to facilitate an expeditious recovery of the motor function after vaginal delivery with epidural analgesia. Future studies should determine if an epidural saline bolus decreases time to full motor recovery, time to readiness for discharge, and what, if any, cost savings are associated with this intervention. Evaluation of these outcomes is important because of the high rate of epidural analgesia administration in the parturient population.

REFERENCES

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