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Patient-controlled epidural analgesia during labor using ropivacaine and fentanyl provides better maternal satisfaction with less local anesthetic requirement

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Abstract
Purpose. To test the hypothesis that patient-controlled epidural analgesia (PCEA) using ropivacaine and fentanyl provides better maternal satisfaction and less anesthetic requirement than conventional continuous epidural infusion (CEI) during labor, we studied 58 uncomplicated parturients (singleton, vertex presentation).
Methods. After establishing effective epidural analgesia with 11 ml of 0.2% ropivacaine, all parturients were randomly divided into one of two groups: the PCEA group (n = 29) or the CEI group (n = 29). In the PCEA group, the pump was initiated to deliver a basal infusion at 6 ml·h^{-1} and a demand dose of 5 ml; the lockout interval was 10 min, and there was a 31 ml·h^{-1} limit. The drugs used were 0.1% ropivacaine + fentanyl 2 μg·ml^{-1}. In the CEI group, epidural analgesia was maintained with the same solution as the PCEA group at a constant rate of 10 ml·h^{-1}. If parturients requested additional analgesia in the CEI group, we added 8 ml of epidural 0.2% ropivacaine without fentanyl.
Results. Parturients' demographic data, such as duration of labor, mode of delivery, Apgar score, and umbilical arterial pH did not differ between the two groups. However, the hourly requirement of ropivacaine was significantly less in the PCEA group than in the CEI group (9.3 ± 2.5 vs. 17.6 ± 7.6 mg·h^{-1}; $P < 0.05$). Parturients' satisfaction assessed by the Visual Analogue Scale tended to be higher in the PCEA group than in the CEI group. Side effects such as nausea, hypotension, and itching were similar for the two groups.
Conclusion. We found that PCEA was an effective means of providing optimal analgesia, with better satisfaction during labor and less local anesthetic requirement.

Key words Labor analgesia · Patient-controlled epidural analgesia · Ropivacaine · VAS satisfaction

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Introduction

Patient-controlled epidural analgesia (PCEA) for labor has become popular in Europe and the United States [1]. However, the adequate concentration of local anesthetics or opioids and their infusion rate, the lockout time, and the bolus dose for PCEA remain controversial. Previous studies using bupivacaine or ropivacaine [2–6] demonstrated that PCEA provided sufficient analgesia with less local anesthetic requirement than conventional continuous epidural infusion (CEI) analgesia. In this study, we hypothesized that the PCEA using ropivacaine and fentanyl for labor also provides better maternal satisfaction with less local anesthetic requirement than CEI. We chose ropivacaine because it is less toxic to the cardiovascular and central nervous systems than bupivacaine.

Materials and methods

After obtaining approval of the institutional investigation committee and informed consent from each parturient, we studied 58 primiparous women with American Society of Anesthesiologists (ASA) physical status I who requested analgesia for childbirth at term with singleton and vertex presentation of the fetus. Exclusion criteria were multiparity, preeclampsia, pregnancy-induced hypertension, multiple gestation, and any contraindication to epidural analgesia such as a bleeding disorder.

Labor was induced electively by infusion of oxytocin at adjusted 2.5 mU·min^{-1} under fetal heart rate monitoring. The infusion rate of oxytocin was adjusted so measured Montevideo units reached 100–150 for the first half of the first stage, 150–200 for the last half of the first stage, and 200–300 for the second stage of labor.

During labor, conventional cardiotocography was used for monitoring to ensure fetal well-being and to

evaluate uterine activity. Maternal blood pressure and heart rate were recorded every 5 min for 15 min after establishing epidural analgesia, after the administration of an additional bolus dose, and once an hour on average.

Prior to epidural analgesia, parturients received an intravenous infusion of 500–1000 ml lactated Ringer's solution. When the Visual Analogue Scale (VAS) of pain (0–100 mm) was higher than 60 mm or the parturient requested analgesia, an epidural puncture was performed with a 17-gauge Tuohy needle by a loss of resistance method using saline at the left lateral position; a catheter was then placed 3–4 cm in the L2–3 or L3–4 epidural space. After confirming the absence of a return of blood or cerebrospinal fluid in the catheter, we injected 3 ml of 0.2% ropivacaine to rule out an intrathecal catheter location. Thereafter, we injected 4 ml of 0.2% ropivacaine twice in 10 min. Fifteen minutes after administering the initial dose, the dermatomal level of loss of coldness was examined using alcohol-soaked cotton.

All parturients were randomly divided into two groups by an envelope method. The PCEA group (n = 29) received anesthetics with a patient-controlled pump (CADD-Legacy PCA, model 6300; Smiths Medical Japan, Tokyo, Japan). The settings of the device were as follows: basal infusion rate at 6 ml·h^{-1}, bolus injection of 5 ml, maximum number of bolus injections at 5 times per hour, and lockout interval of 10 min. The CEI group (n = 29) received anesthetics with a syringe pump (1235N; ATOM, Tokyo, Japan) at a constant rate of 10 ml·h^{-1}. Epidural anesthetic solutions in the two groups were the same: 0.1% ropivacaine mixed with 0.0002% fentanyl. If parturients of the CEI group complained of pain and required pain relief, an additional 8 ml of 0.2% ropivacaine was administered through the epidural catheter.

We recorded the Visual Analogue Scale (VAS) of pain before epidural administration, after checking hypoesthesia levels to cold, and at the time of delivery. After delivery, the number of additional analgesic administrations was reviewed with a recorder in the PCA pump for the PCEA group. The additional analgesic doses and the total doses were then calculated for both groups. After the delivery and removal of the pump, midwives interviewed the parturients about their satisfaction of analgesia using the VAS.

Anesthetic complications such as nausea, hypotension, and itching were noted as a yes/no occurrence. Hypotension was defined as a more than 30% decrease in systolic blood pressure from the value before the analgesia. It was treated with intravenous fluid administration or ephedrine 5 mg i.v.

Demographic data, dose of anesthetic, outcome of labor, and side effects were analyzed with the Mann-Whitney test. Data were expressed as the mean ± SD or the median and range as appropriate. $P < 0.05$ was considered statistically significant.

Results

The demographic data were not significantly different between the two groups (Table 1). The VAS of pain before analgesia was 74 (range 55–94) in the PCEA group and 70 (50–100) in the CEI group. The dermatomal hypoesthesia level for cold on the right and left sides in the PCEA group were T11 (T6-L1) and T10 (T4-L1) respectively. Those in the CEI group were T10 (T4-L1) and T10 (T4-L1), respectively, at establish-

Table 1. Demographic data and delivery outcome

Parameter	PCEA group (n = 29)	CEI group (n = 29)
Age (years)	29 ± 5	30 ± 4
Height (cm)	160.1 ± 5.3	159.6 ± 5.1
Weight (kg)	62.7 ± 7.4	63.6 ± 8.7
Gestational week	39.7 ± 1.2	39.3 ± 1.3
Cervical dilation (cm)	4 (1–6)	3 (1–7)
Duration of labor		
First stage (h)	3.8 ± 2.5	3.3 ± 2.3
Second stage (h)	2.7 ± 2.0	1.9 ± 1.6
Mode of delivery		
Spontaneous	13 (45%)	16 (55%)
Instrumental (forceps/vacuum)	1/15 (3%/51%)	0/13 (0%/45%)
Apgar score		
1 min	8 (8–9)	8 (8–9)
5 min	9 (8–10)	9 (8–10)
Umbilical arterial pH	7.29 ± 0.05	7.30 ± 0.04

Results are the mean ± SD; median (range); or number (%)

Table 2. Hourly doses of local anesthetic and fentanyl

Parameter	PCEA group (n = 29)	CEI group (n = 29)
Local anesthetic		
Basal dose (mg·h^{-1})	6	10
Additional dose (mg·h^{-1})	3.3 ± 2.5	7.6 ± 7.6
Total dose (mg·h^{-1})*	9.3 ± 2.5	17.6 ± 7.6
Fentanyl		
Basal dose (μg·h^{-1})	12	20
Additional dose (μg·h^{-1})	6.6 ± 4.1	0
Total dose (μg·h^{-1})	18.6 ± 4.1	20.0 ± 0

Results are the mean ± SD
* $P < 0.05$

Table 3. Complications of anesthesia

Complication	PCEA group (n = 29)	CEI group (n = 29)
Nausea	1 (3.4%)	0
Hypotension	0	0
Pruritus	2 (6.9%)	2 (6.9%)

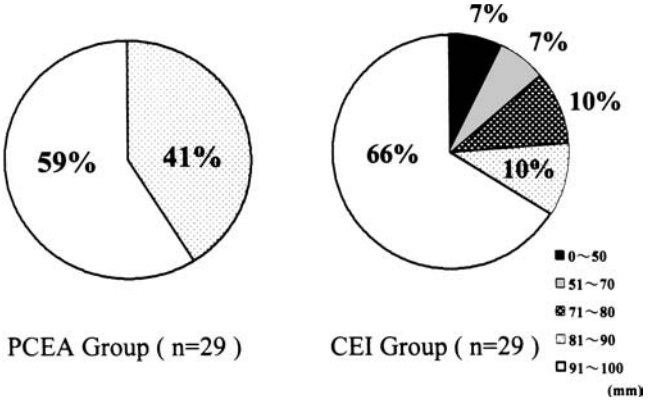

Fig. 1. Satisfaction of parturients using the Visual Analogue Scale (VAS). All parturients in the patient-controlled epidural anesthesia (PCEA) group showed satisfaction with the labor analgesia using a VAS above 81 mm, whereas 24% of parturients of the conventional continuous epidural infusion (CEI) group showed satisfaction below 70 mm

ment of analgesia. The duration of labor, incidence of instrumental delivery, Apgar score, and umbilical arterial pH were not significantly different between the two groups.

The basal dose of local anesthetic was higher in the CEI group by 4 mg for each hour than in the PCEA group. The total dose per hour in the CEI group was also significantly higher than in the PCEA group ($P < 0.05$) (Table 2). The additional local anesthetic dose for each hour was not significantly different between the two groups.

Satisfaction about labor analgesia using the VAS scale is shown in Fig. 1. In the PCEA group, the "satisfactory" VAS was above 81 mm in all patients. In the CEI group, 24% of parturients had a VAS of less than 80 mm, and 14% parturients had a VAS of less than 50 mm. The incidences of nausea, hypotension, and itching were not significantly different between two groups (Table 3).

Discussion

We found that PCEA provides better satisfaction with less local anesthetic than does CEI when we used ropivacaine with 0.0002% fentanyl. The ropivacaine dose in the PCEA group was less than that in the CEI group by 35%. This is consistent with the results of previous studies, which reported that use of PCEA can reduce the local anesthetic requirement by 42%–47% compared to CEI [7–10]. Some studies [11,12] with PCEA using ropivacaine also demonstrated that PCEA reduces drug consumption (17.6% and 24.9%, respectively) compared to CEI. However, PCEA was programmed with a demand-only regimen in those studies, so it is not appropriate to compare their results with ours.

One of the advantages of reducing the local anesthetic requirement during labor analgesia is that it decreases the degree of motor blockade [13] and the number of instrumental deliveries [14,15]. Not only the dose of the local anesthetic but the characteristics of the drug affect the degree of motor block. Both bupivacaine and ropivacaine have been used in obstetrical analgesia practice [1–10] because of the low placental transfer of the drugs and the high quality of the

analgesia. Toxicity to the cardiovascular and central nervous systems is greater with bupivacaine than with ropivacaine [16,17]. Furthermore, ropivacaine is associated with less motor blockade [18]. Therefore, we chose ropivacaine instead of bupivacaine to overcome these drawbacks.

Prior to the establishment of epidural analgesia, we did not use a test dose solution containing epinephrine. Recent studies [19,20] have shown that aspiration could detect almost all intravenous migration of a multiorifice catheter in laboring women. Norris et al. [20] recommended that practitioners consider abandoning the routine use of epinephrine in a test dose when providing epidural labor analgesia with a multiorifice catheter and using dilute local analgesic solutions.

In this study, the basal dose of the same study solution in the PCEA group was 6 ml·h^{-1}, whereas that in the CEI group was 10 ml·h^{-1}. Despite the higher basal dose in the CEI group, they tended to use a higher dose of additional ropivacaine than in the PCEA group. One of the reasons for this might be related to the possibility that addition of fentanyl to the rescue solution in the PCEA group may hasten the onset of analgesia [21].

As far as the dose of additional epidural anesthetic is concerned, Lee et al. [22] used 5–10 ml of 0.25% ropivacaine, and Collis et al. [23] used 10–15 ml of 0.2% ropivacaine with fentanyl 2 μg·ml^{-1} for breakthrough pain during labor. Therefore, we believe that 8 ml of 0.2% ropivacaine is appropriate and safe for labor. However, it is possible that the content and dose of additional local analgesic affects the results.

Several points should be considered as the reason for the superiority of PCEA to CEI. First, the time interval from pain sensation to drug administration was longer in the CEI group than in the PCEA group. When the parturients in the CEI group felt labor pain, they complained to the midwives, and they in turn informed a doctor. The doctor then injected the local anesthetics. This long process might cause parturient anxiety, resulting in augmentation of pain and additional local anesthetic requirement. Parturients in the PCEA group could obtain the drug injection upon their request. Curry et al. [10] reported that PCEA could reduce a dose of 0.125% bupivacaine by 43% compared to CEI. They also noted significantly higher satisfaction with PCEA than with CEI.

Second, PCEA by itself might bring high satisfaction of analgesia to the parturients [10]. This is because parturients in the PCEA group could inject the analgesic themselves and lessen their own pain. According to van der Vyver [24], it is difficult to evaluate a parturient's satisfaction because it includes many factors, such as the parturient's expectation for labor analgesia, the quality of communication with the medical team, and the outcome of labor. He investigated nine reports and found that VAS satisfaction was extremely high with both PCEA and CEI; there were no significant differences between two groups in all reports. Therefore, we must consider the quality of communication with parturients our their impression about the outcome of labor. In our study, VAS satisfaction of parturients after delivery tended to be higher in the PCEA group. Narrative comments on pain relief in both groups were as follows. In the PCEA group, some parturients mentioned that their labor pain was relieved before it became severe using a rescue agent by pushing the PCEA button. They experienced slight pain, and others said that they had had no labor pain at all after initiation of epidural analgesia. On the contrary, parturients who showed low VAS satisfaction in the CEI group mentioned that they had to wait to receive the effect of analgesics, and others said that they felt severe pain several times during labor because they hesitated to request a rescue bolus dose from the medical staff.

The outcome of labor, or the effect on the fetus, is another issue to be considered. In our study, the parameters analyzed were not significantly different between the two groups. These results were similar to those of previous investigations [7–12]. Finally, one may argue that the nonblinded setting in this study might influence the results of the consumption of analgesics and the satisfaction score.

Conclusion

PCEA is an effective means of providing optimal analgesia and better satisfaction during labor with less local anesthetic requirement compared with the conventional CEI.

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