

Comparison of Continuous Epidural and Intravenous Analgesia for Postoperative Pain Control in Pediatric Lower Extremity Surgery

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In recent years epidural anesthesia and analgesia techniques were used in pediatric surgery owing to the development of pediatric epidural catheter needles. And the need of postoperative pain control in pediatric patients is also increasing. We compared combined general-epidural anesthesia and analgesia technique with intravenous fentanyl analgesia after general anesthesia for postoperative analgesic effect and complications in these pediatric patients. We randomly allocated 91 pediatric patients undergoing lower extremities surgery into epidural lidocaine group (n=61) and IV fentanyl group (n=30). During the operation, end-tidal sevoflurane concentration (ET_{sev}) was controlled to maintain the blood pressure and heart rate within 10% of preoperative value. At the postoperative period, Parent Visual Analog Scale (PVAS), Objective Pain Score (OPS) and the incidence of nausea/vomiting were checked immediately, 6 hours and 24 hours after the patient's arrival at general ward. ET_{sev} was significantly low in epidural lidocaine group ($p < 0.05$). Compare to IV fentanyl group, epidural lidocaine group had significantly lower OPSs at 6 hours after arrival. Epidural lidocaine group had significantly lower PVASs immediately, 6 hrs and 24 hours after arrival. There was no significant difference in the incidence of postoperative nausea and vomiting. A combined general-epidural anesthesia technique significantly reduces intraoperative end-tidal sevoflurane concentration compared to general anesthesia alone. And continuous patient-controlled epidural analgesia reduces postoperative pain scores significantly more than continuous patient-controlled IV fentanyl

analgesia without any serious complications in pediatric lower extremity surgery.

Key Words: Children, epidural analgesia, intravenous analgesia, lidocaine, fentanyl

INTRODUCTION

Since Campbell reported pediatric caudal anesthesia in 1933,¹ this technique has been conducted for pediatric lower abdominal or limb surgery. The use of regional anesthesia is increasing with the importance of postoperative pain control.²

Single injection caudal anesthesia and analgesia is usually performed in short-term operations, such as hernioplasty or urologic operations.³ However in long-term operations such as pediatric lower limb surgery, general anesthesia was used in the past. Recent improvements in the pediatric epidural needle and catheter make it possible to continuously infuse drugs into the epidural space during pediatric surgery.^{4,5} But the risk of local anesthetic toxicity increases as the length of surgery is prolonged and additional dose of local anesthetic is used.⁶ While, the combined general-epidural anesthesia can reduce the need of both local and inhalation anesthetics^{7,8} and make the postoperative pain control effective.

While caudal anesthesia is easier to perform, it has a greater risk of infection and more difficult to manage the catheter.⁹⁻¹¹ Lumbar epidural anesthetics are more commonly used compare to

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caudal anesthesia.

In this study, we compared combined general-epidural anesthesia and analgesia with intravenous analgesia after general anesthesia for postoperative analgesic effect and complications in pediatric patients.

MATERIALS AND METHODS

After approval from the university's ethics committee, we recruited 91 male and female children (1-14 years old), ASA physical status I or II undergoing elective lower extremity surgery requiring bilateral or multiple incision due to poliomyelitis, spastic cerebral palsy, or congenital hip dislocation. The aims and methods of this study were explained to all the caregivers when they visited the hospital before surgery and then oral consent was obtained. Those who had inflammation on the skin around the puncture site or who had spastic cerebral palsy and already had undergone lumbar laminectomy due to selective posterior rhizotomy for alleviation of spasticity were excluded from epidural catheter insertion group.

For the preoperative medications, glycopyrrolate 0.004 mg kg^{-1} was injected intramuscularly an hour before induction of anesthesia. In the preoperative room, thiopental sodium 3 mg kg^{-1} I.V. was given to all pediatric patients for sedation when the caregivers were present and the patients were then transferred to the operating room. All the monitors including pulse oxymeter, ECG monitor, and noninvasive blood pressure were applied. Additional 3 mg kg^{-1} of thiopental sodium and 0.6 mg kg^{-1} of rocuronium was injected intravenously. Endotracheal intubation was performed after confirming complete muscle relaxation. When there was no contraindication for epidural catheter insertion, the patients were randomly allocated in either general anesthesia with continuous epidural anesthesia analgesia group (group E) or general anesthesia with fentanyl intravenous infusion group (group I). As for Group E, the 18 G 5cm pediatric Tuohy needle (Perican[®], B. Braun, Melsungen, Germany) was inserted. A loss-of-resistance technique is used to find the epidural space. As 20 G epidural catheter (Perifix,

B. Braun, Melsungen, Germany) was inserted, the end of the catheter was located in the L2-L3.

After ensuring that no cerebrospinal fluid or blood was aspirated through the catheter, the authors infused the mixture of 1% lidocaine (0.7 ml kg^{-1}) and fentanyl ($1 \mu\text{g kg}^{-1}$) with epinephrine at the ratio of 1:200,000 through the epidural catheter.

At the first skin incision, the ETsev was controlled so that the vital signs were maintained at the range of 10 % of the baseline and was recorded at 30 minutes, 1 hour, and 2 hours after the start of the surgery. However, when the blood pressure was less than 80% of the baseline in 1.25 vol % of sevoflurane, 1.0-2.0 mg of ephedrine was injected intravenously to maintain the pressure.

5 ml of 0.5% lidocaine was bolused through the epidural catheter 10-15 minutes before the surgery was over. 100ml of 0.5% lidocaine was mixed into the patient controlled continuous infuser (Accufuser Plus[®]), Woo Young Medical, Paju, Korea) in which basal rate was 1.0 ml hr^{-1} , bolus was 0.5 ml, and lockout time was 8 min. to be connected with the epidural catheter.

As for Group I, after general anesthesia, $24 \mu\text{g kg}^{-1}$ of fentanyl citrate ($100 \mu\text{g ml}^{-1}$, Hana Pharm. Co., Ltd., Korea) was mixed with physiological saline (total volume 100 ml) and infused by 0.25 and $1.0 \mu\text{g kg}^{-1} \text{ hr}^{-1}$ until 48 hours after surgery. The use of the bolus button was permitted to the caregivers.

The degrees of pain (using the Parent Visual Analog Scale (PVAS) and Objective Pain Score (OPS, Table 1)^{12,13} and the degrees of sedation (using the Sedation Score, Table 2)¹⁴ were assessed immediately, 6 hours and 24 hours after the patient's arrival at general ward. Whether complications such as nausea & vomiting, dysuria, pruritus, and respiratory depression existed was identified.

All the results were expressed as mean \pm SD. The demographic data between the two groups and PONV were compared by chi-square test, while end-expiratory sevoflurane concentration was compared by Student t-test, and OPS and PVAS was by Mann-Whitney U-test). A probability value of < 0.05 was considered significant.

Table 1. Objective Pain Score (OPS)

BP	+ 10% preop	0
	10% to 20% preop	1
	> 20% preop	2
Crying	not crying	0
	crying but consolable	1
	crying, not consolable	2
Movement	none	0
	restless	1
	thrashing	2
Agitation	asleep or calm	0
	mild	1
	hysterical	2
Verbal evaluation or body language	asleep or states no pain	0
	mild pain (cannot localize)	1
	moderate pain (can localize)	2
	verbally or by pointing	2

Table 2. Sedation Score

Eyes open spontaneously	0
Eyes open to speech	1
Eyes open when shaken	2
Unrousable	3

RESULTS

No significant differences were found between the groups with respect to sex, age, weight, height (Table 3).

The ETsev of Group E was 1.5 ± 0.5 vol % on the first skin incision, 1.2 ± 0.5 on the 30th minute, 1.0 ± 0.5 on the 1st hour, 1.1 ± 0.5 on the

2nd hour of the surgery, while that of Group I was 2.3 ± 0.6 , 2.1 ± 0.5 , 2.0 ± 0.5 and 1.9 ± 0.7 , respectively. Therefore, the ETsevo of Group E was maintained significantly lower when compared to that of Group I ($p < 0.05$; see Fig. 1).

The postoperative OPS were significantly lower in Group E (2.3 ± 2.0) than Group I (3.2 ± 1.8) at 6 hours after arrival at general ward ($p < 0.05$; see Fig. 2).

The postoperative PVAS of Group E was 3.8 ± 2.6 immediately after arrival, 2.7 ± 2.2 on the 6 hours, and 1.6 ± 2.0 on the 24 hours after arrival, while that of Group I was 4.9 ± 2.2 , 4.3 ± 2.1 , and 2.2 ± 1.5 , respectively. Therefore, the postoperative PVAS was significantly lower in Group E than Group I ($p < 0.05$; see Fig. 3).

The frequency of postoperative nausea and

Table 3. Demographic Data

	I Group (N=30)	E Group (N=61)
Sex (M/F)	22 / 8	35 / 26
Age (yrs)	6.2 (3.4-9)	7.3 (4.5-10.1)
Weight (kg)	20.8 (13.6-28)	24.1 (14.7-33.5)
Height (cm)	111.3 (90.9-131.7)	117.2 (97.7-136.7)

Data are mean (SD or range)

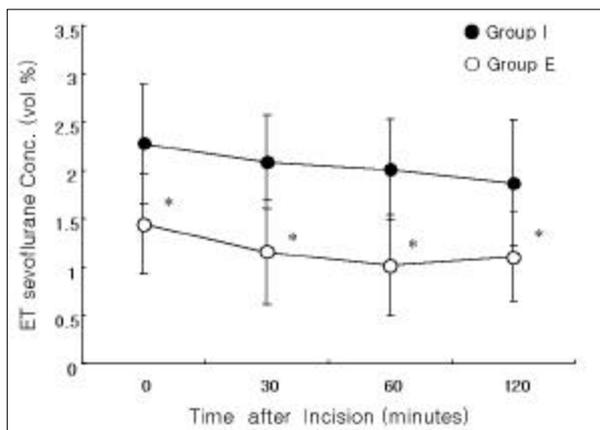


Fig. 1. Comparison of intraoperative end-tidal concentration of sevoflurane (mean \pm SD) at time sequences between epidural lidocaine group (□ group E, N=61) and intravenous fentanyl group (● group I, N=30). There are significant differences ($*p < 0.05$) in the end-tidal concentration of sevoflurane at each time sequences between groups. Lower end-tidal concentration of sevoflurane was maintained in group E at the time of skin incision, 30, 60 and 120 min after skin incision.

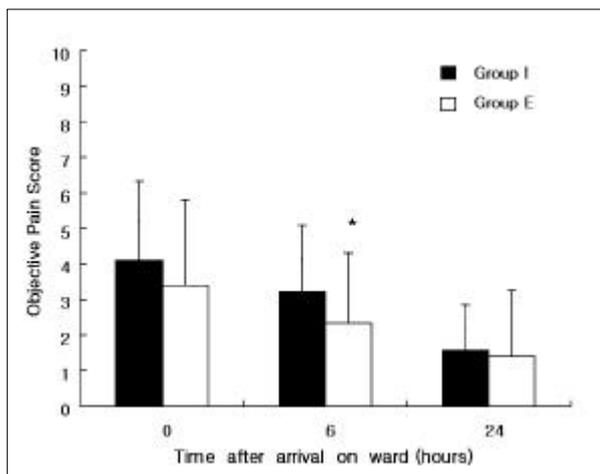


Fig. 2. Comparison of Objective Pain Score (OPS, mean \pm SD) between epidural lidocaine group (□ group E, N=61) and intravenous fentanyl group (■ group I, N=30). $*p < 0.05$ group I vs. group E. OPS (0-10) was measured at the time of arrival on ward, 6 hours and 24 hours after arrival on ward.

vomiting was 16.4% (10/61) in Group E and 30% (9/30) in Group I. Although the percentage of Group I was higher than Group E, there was no statistical significance. Nine out of Group E and four out of Group I complained of dysuria.

As for Group E, no serious adverse effects such as the postoperative infection in the area of dura

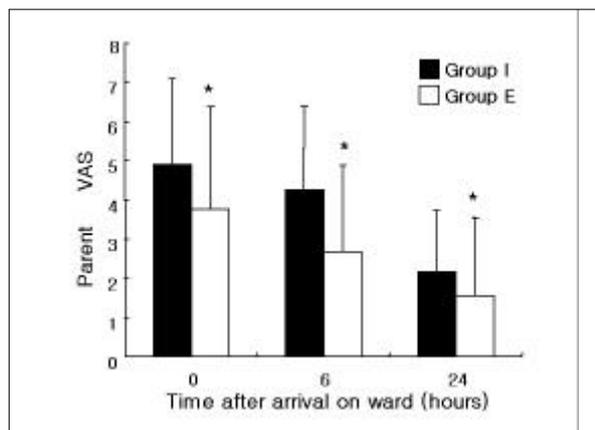


Fig. 3. Comparison of Parent Visual Analog Scale (PVAS, mean \pm SD) between epidural lidocaine group (□ group E, N=61) and intravenous fentanyl group (■ group I, N=30). $*p < 0.05$ group I vs. group E. The PVAS was asked to the children's parents at the time of arrival on ward, 6 hours and 24 hours after arrival on ward. The parents of group E scored lower PVAS at the time of arrival on ward, 6 hours and 24 hours after arrival on ward.

mater puncture or catheter insertion, the neurological symptoms in the lower limbs, and convulsion were observed. Also in Group I, there was no patient whose sedation score was more than 2 points or who complained of pruritus, and no serious adverse effects such as respiratory depression were observed.

DISCUSSION

In this study, pediatric patients who underwent surgery in the lower limbs requiring multiple incisions were selected as the subjects for comparing combined general-epidural anesthesia and patient-controlled epidural analgesia with general inhalation anesthesia and patient-controlled intravenous analgesia. A combined general-epidural anesthesia significantly reduces intraoperative end-tidal sevoflurane concentration compared to general anesthesia alone. And continuous patient-controlled epidural analgesia reduces postoperative pain scores significantly more than continuous patient-controlled IV fentanyl analgesia without any serious complications in pediatric lower extremity surgery.

The end-tidal concentration of sevoflurane was

significantly low during the surgery when epidural anesthesia was combined in this study. Similarly, some researchers reported that the requirement of hypnotics, such as midazolam, was reduced in spinal anesthesia or epidural anesthesia,^{15,16} or that the requirement of isoflurane or sevoflurane was decreased in epidural anesthesia.^{17,18} Gentili et al. reported that in the patients who received bupivacaine spinal anesthesia, degree of sedation was closely related to the level of blockage¹⁹ by way of Observer-Rated Scale of sedation. They theorized that decline in the tonic afferent sensory input from spinal cord decrease the cerebral awareness. Hodgson et al.²⁰ suggested that 34% reduction in end-expiratory sevoflurane concentrations in lidocaine epidural anesthesia group compared to the control group without lidocaine epidural anesthesia in order to reach the BIS[®] value below 50. The tonic afferent input toward cerebrum was blocked not by the general effect of lidocaine but by the epidural anesthesia. Such afferentation theory, that the activity of afferent sensory input or muscle-spindle maintains wakefulness,²¹ was explained by Lanier et al. in 1994.

Meanwhile, other researchers suggest that subarachnoid or epidural lidocaine might move toward cerebrum and produce the effect of general anesthesia from the local anesthetic.²²

Recently, as many studies report the usefulness and safety of postoperative epidural pain control on pediatric patients²³ and many new local anesthetics and epidural catheters for children are introduced. Recently, continuous epidural analgesia (CEA) or patient controlled epidural analgesia (PCEA) has been proven to be effective and safe,²³⁻²⁵ and favorable for postoperative prognosis. Pediatric patients who underwent PCEA were apparently quickly recovered to eat normal diet and discharged 0.5 day earlier when compared to those who underwent intravenous patient controlled analgesia.²⁶ In this study, PCEA using of lidocaine was proven to be effective and safe on pediatric patients.

As for postoperative analgesia effect, the PVAS of Group E was significantly lower than that of Group I immediately, 6 and the 24 hours after the patients went back to ward. The OPS of Group E was significantly lower than that of Group I only

on the 6 hours after returning to the ward. The OPS was assessed by the medical personnel, but PVAS is a subjective assessment and excludes the bias of the assessor. PVAS drew out remarkably high satisfaction from Group E, and OPS also was assessed to be superior by Group E, though some biased view might be permitted because of the absence of the assessor's subjectivity.

In the OPS, Group E showed a lower value than Group I only on the 6 hours after the patients return to the ward, and this might be because not only the limitation in the number of samples but also the quantitative aspect of the pain assessment scores failed to show.²⁷ Meanwhile, Group E in this study showed favorable results in the postoperative pain control, and this might be partly because the dose of fentanyl was small or the intravenous line was hard to be found for Group I. However, the dose of fentanyl in this study was similar to the recommended one ($0.5-2 \mu\text{g kg}^{-1} \text{hr}^{-1}$),²⁸ thus being not a small dose.

To avoid respiratory depression or loss of consciousness in Group I, we choose the smaller dose within the recommended dose.

In the postoperative nausea and vomiting (PONV), Group E was 16.7% while that of Group I was 30%. Despite no statistical significance, PONV was observed more in Group I than Group E.

There are other complications associated with the insertion of epidural catheter such as dura mater puncture, the subdural or subarachnoid insertion of catheter, nerve damage, epidural hematoma, intravenous infusion, meningitis, epidural abscess, and the infection around the catheter and the deep tissue, but no such complication was observed in this study. The severe delayed complication associated with catheter insertion was the infection induced by catheter, and in particular, the intravertebral infection. Kost-Byerly et al.¹¹ reported that, in 35% of the catheters after continuous epidural infusion through lumbar or coccygeal epidural catheter insertion, colony was found, and the colonization of gram-positive strains was 23% (9/40) in the lumbar catheters and 25% (73/210) in the coccygeal catheters, while the colonization of gram-negative strains was 3% (1/40) in the lumbar catheters and 16% (27/170) in the coccygeal catheters. However, such coloni-

zations did not related severe general or local infection because the duration of the catheter insertion was short. In this study, although active examinations such as strain cultivation were not used, the duration of the catheter insertion was short, and no evidence of infection was found in general clinical symptoms. Meanwhile, two patients out of Group E removed the epidural catheters earlier. One of them had no analgesia effect and the other one had preoperative nausea and vomiting. The parents wanted the catheter to be removed when the symptoms were aggravated postoperatively.

The combined general-epidural anesthesia and epidural analgesia in pediatric patients have a difficulty in actual application due to various problems such as the management of catheter, systemic toxicity of local anesthetics, the infection of the insertion area, the insufficiency of the understanding of the caregivers and the pediatric patients about the pain-controlled analgesia (PCA), and the determination of the person who use the bolus button (the caregiver or the patient).

When 1% lidocaine epidural anesthesia was combined with sevoflurane general anesthesia for the pediatric patients requires multiple-incision in their lower-limbs (Group E), the end-expiratory requirement of sevoflurane was reduced compared to those of Group I which had only sevoflurane general anesthesia. Also, the subjects of Group E who were continuously infused with 0.5% lidocaine by epidural catheter as a method of PCA showed more effective postoperative pain control when compared to the subjects of Group I who were given fentanyl IVPCA.

In conclusion, the combined general-epidural anesthesia for the pediatric patients who required multiple-incision in their lower-limbs can provide effective and safe anesthesia as well as postoperative analgesia without severe complications.

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