Pediatric patients with cerebral palsy are likely to suffer severe pain postoperatively. Muscle spasticity can be increased by pain stimuli, and may further increase pain to create a vicious cycle. Moreover, difficulties in pain assessment associated with poor verbal communication skills and the concerns of parents and medical personnel about the side effects of analgesics may result in insufficient pain control\(^6,17\).

Although several methods of reducing pain and spasticity have been proposed in non-operatively treated patients with cerebral palsy\(^1,4,14,18\), adequate and specialized methods of postoperative pain management in this group of patients have yet to be established. In this study, we evaluated the efficacy and safety of intravenous patient-controlled analgesia (PCA) with fentanyl and ketorolac versus the pethidine-based conventional analgesic method after orthopaedic surgical procedures.

**Purpose:** The purpose of this study was to evaluate the safety and efficacy of intravenous patient-controlled analgesia (PCA) with fentanyl and ketorolac for postoperative pain management in patients with cerebral palsy.

**Materials and Methods:** Sixty patients were categorized based on operation complexity into either a minor operation group or a major operation group, and then subdivided based on the analgesic methods used, i.e., intravenous PCA with fentanyl and ketorolac or intravenous pethidine injection. Pain intensity was assessed using the Wong-Baker’s faces pain scale.

**Results:** In the major operation group, patients that received PCA had significantly lower pain scores than those who received intravenous pethidine injection, while no significant differences in pain scores were observed in the minor operation group. Moreover, the side effects of these two analgesic methods did not differ significantly.

**Conclusion:** Intravenous PCA with fentanyl and ketorolac is effective and safe for moderate to severe postoperative pain control in pediatric patients with cerebral palsy.

**Key Words:** Intravenous patient-controlled analgesia, Fentanyl, Ketorolac, Pethidine, Postoperative pain, Cerebral palsy
Intravenous Patient-controlled Analgesia for Postoperative Pain Management in Patients with Cerebral Palsy

The patients were then further subdivided based on the analgesic method used into intravenous PCA with fentanyl and ketorolac, or intravenous pethidine injection. Patients were matched in these groups for age and sex. Summarizing, the 60 patients were allocated to four groups: group I (minor operation/PCA, n=16), group II (minor operation/pethidine, n=18), group III (major operation/PCA, n=14), and group IV (major operation/pethidine, n=12) (Table 1).

The PCA unit was composed of a basal infusor and a patient control module (AutoMed 3,300<sup>®</sup>, Ace Medical Inc., Seoul, Korea). The PCA regimen used was fentanyl citrate (15 mcg/kg) and ketorolac tromethamine (2.5 mg/kg) mixed in D5W to a total volume of 50 mL. Drugs were infused continuously at the rate of 0.4 mL/hr and a bolus amount of 0.6 mL/injection was administered by button pressing. The ‘lock out’ time interval between allowed bolus deliveries was set at 15 min. PCA drug administration commenced immediately after a patient left the recovery room. Pethidine HCl was administered intravenously at 1 mg/kg (maximum 40 mg) whenever patient or parent required, but with a minimum injection interval of four hours. All patients were given the antispasmodic, diazepam, at a daily dose of 0.2 mg/kg.

Pain intensity was assessed at two hours postoperatively, and then every six hours for 50 hr using the Wong-Baker faces pain scale.<sup>17</sup> (Fig. 1). The total amount of drugs delivered by the PCA system was determined by adding the bolus volume to the basal infusion volume over 50 hr postoperatively, and the total amount of pethidine injected was calculated from the number of the injections recorded on medical charts. Any side effects such as respiratory depression, nausea, vomiting, somnolence, itching, and headache were notified to the doctor on duty and recorded.

Pain scores by the analgesic methods were compared for each operation group. Repeated ANOVA (SPSS version 10.0, SPSS Institute, Chicago, USA) was used for the statistical analysis, and p values of <0.05 were considered statistically significant.

**RESULTS**

In the major operation group, PCA with fentanyl and ketorolac produced significantly lower pain scores than pethi-
dine injection (p=0.032). Initially, the pain scores of the two analgesic methods were similar, but the pain relieving effect of the PCA method became significantly superior to that of pethidine injection at 20 hr postoperatively and this was sustained (p=0.031). In the minor operation group, the pain control achieved by the two analgesic methods was similar (Fig. 2). The total doses of drugs administered are shown in Table 2. Side effects such as nausea, vomiting, somnolence, itching, headache, and respiratory depression occurred infrequently, and they did not differ significantly by analgesic method (Table 3). In no case were the side effects severe enough for the drug administration to be changed or stopped.

**DISCUSSION**

Ketorolac coadministration with intravenous fentanyl PCA resulted in reduced pain ratings after total hip replacement surgery or radical retropubic prostatectomy. Prolongation of bleeding time caused by the inhibition of prostaglandin synthesis, which occurs with ketorolac and other NSAIDs, may be associated with gastrointestinal ulceration and an increased risk of acute renal failure in some clinical conditions. In major orthopedic surgery, however, there is no evidence of an interaction with NSAIDs that could increase postoperative blood loss. Several reports have shown that ketorolac has an opioid-sparing effect in pain management after orthopaedic surgery. Fentanyl has a high protein binding capacity, about 84% is protein bound in vivo, and ketorolac is approximately 99.2% bound to plasma albumin. Thus, ketorolac may compete with fentanyl for protein binding and possibly potentiate the action of fentanyl by increasing the unbound fraction of fentanyl, as other non-steroid

<table>
<thead>
<tr>
<th>Group</th>
<th>Fentanyl (mcg/kg)</th>
<th>Ketorolac (mg/kg)</th>
<th>Pethidine (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>8.71</td>
<td>1.45</td>
<td>N</td>
</tr>
<tr>
<td>Group II</td>
<td>N</td>
<td>N</td>
<td>3.33</td>
</tr>
<tr>
<td>Group III</td>
<td>10.89</td>
<td>1.82</td>
<td>N</td>
</tr>
<tr>
<td>Group IV</td>
<td>N</td>
<td>N</td>
<td>5.30</td>
</tr>
</tbody>
</table>

PCA, patient-controlled analgesia; N, none.

**Table 3. Side effects**

<table>
<thead>
<tr>
<th></th>
<th>PCA with fentanyl and ketorolac</th>
<th>Intravenous pethidine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory depression</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nausea</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Vomiting</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Somnolence</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Itching</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Headache</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

PCA, patient-controlled analgesia.
Intravenous Patient-controlled Analgesia for Postoperative Pain Management in Patients with Cerebral Palsy

We assessed pain using a self reporting method, the Wong-Baker faces pain scale. Several studies have confirmed the validity and reliability of this scale for children. It is generally accepted that self reporting is the most effective method of pain measurement, and that children older than five years can reliably self report pain intensity. Other pain assessing parameters like behavioral scoring or the length of hospital stay could not be used in this study, because many patients were placed in a cast or an immobilizer postoperatively, and hospital stay might have been determined by factors like postoperative fever, wound problems, or secondary procedures.

Surgical procedures performed in groups I and II were similar in terms of number, procedure complexity, and expected pain. However, a larger number of operations on soft tissues were performed in group III (mean 3.6 operations/patient) than in group IV (mean 2.6 operations/patient) while osteotomy complexities were similar in group III (19 femoral, 1 calcaneal, and 1 pelvic osteotomies) and group IV (13 femoral, 3 tibial, and 3 calcaneal osteotomies). Therefore, the statistical results strongly suggest that the analgesic effect of PCA with fentanyl and ketorolac is superior to that of pethidine by injection for major operations. In contrast, the relative infusion amount of pethidine to fentanyl in the minor operation group (3.33/8.71, 38.2%) was lower than that in the major operation groups (5.30/10.89, 48.7%), while the analgesic effects of the two methods were similar in the minor operation groups. In addition, three of the 18 patients in group II did not need any pain control. These findings suggest that conventional on demand pethidine injections may still be an appropriate analgesic method for patients undergoing minor operations involving soft tissue procedures only. However, caution should be exercised concerning the prolonged use of pethidine, because it has been associated with seizure occurred at high doses, and with other central nervous system toxicities, such as, nervousness, hyperreflexia, tremors and myoclonus.

In view of finding that the analgesic benefit of the PCA method was not apparent until 20 hr after major operation and that an unnecessary amount of drug was administered due to the continuous basal infusion setting of the PCA system in minor operations, some modification of the current PCA method, including changes in drug concentration, drug regimen, and basal flow rate may be justified.

CONCLUSION

In conclusion, intravenous PCA with fentanyl and ketorolac was found to be an effective and safe modality for moderate to severe pain control after orthopaedic surgery in pediatric patients with cerebral palsy. However, in minor operations where mild pain is expected, it appears not to have a definite advantage over conventional ‘on demand’ pethidine injection.

REFERENCES

뇌성마비 환자에서 수술 후 통증 조절을 위한 경정맥 자가 통증 치료법

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목적: 뇌성마비 환자에서 fentanyl과 ketorolac을 이용한 경정맥 자가 통증 치료법(intravenous patient-controlled analgesia)의 수술 후 통증 조절에 대한 안전성과 효용성에 대한 평가하였다.

대상 및 방법: 60명의 환자를 대상으로 수술의 복잡성에 따라 대 수술과 소 수술로 나누어 두 군으로 분류하였고 각 군을 수술 후 통증 조절 방법에 따라 fentanyl과 ketorolac을 이용한 경정맥 자가 통증 치료법을 사용한 군과 pethidine 정맥주사를 사용한 군으로 세분하였다. 통증의 강도는 Wong-Baker's faces pain scale에 따라 평가하였다.

결과: 대 수술군에서는 경정맥 자가 통증 치료법을 사용한 환자군의 통증 감소 효과가 높았고 소 수술군에서는 경정맥 자가 통증 치료법을 사용한 환자군의 통증 감소 효과가 높았다. Fentanyl과 ketorolac을 이용한 경정맥 자가 통증 치료법의 부작용은 보이지 않았다.

결론: Fentanyl과 ketorolac을 이용한 경정맥 자가 통증 치료법은 뇌성마비 소아 환자에서 수술 후 중등도 이상의 통증 조절에 있어 안전하고 효과적이다.

색인 단어: 경정맥 자가 통증 치료법, Fentanyl, Ketorolac, Pethidine, 수술 후 통증, 뇌성마비