British Journal of Anaesthesia 1993; 71: 670–673

COMPARISON OF PATIENT-CONTROLLED ANALGESIA WITH AND WITHOUT A BACKGROUND INFUSION AFTER LOWER ABDOMINAL SURGERY IN CHILDREN

E. DOYLE, D. ROBINSON AND N. S. MORTON

SUMMARY

Forty children aged 6–12 yr undergoing appendicectomy were allocated randomly to receive postoperative i.v. morphine by a patient-controlled analgesia (PCA) system (bolus dose 20 μg kg^{-1} with a lockout interval of 5 min) or the same PCA with a background infusion of morphine 20 μg kg^{-1} h^{-1}. Patients breathed air and oxygen saturation was monitored by continuous pulse oximetry. Scores for pain, sedation and nausea were recorded hourly. Patients with PCA + background infusion received significantly more morphine than those with PCA only. Both groups self-administered similar amounts of morphine using the PCA machine. There were no significant differences in the pain scores of the two groups. Patients with PCA + background infusion suffered more nausea ($P < 0.01$), more sedation ($P < 0.05$) and hypoxaemia ($P < 0.001$) than those with PCA only. They also had a better sleep pattern than those with PCA only. (Br. J. Anaesth. 1993; **71**: 670–673).

KEY WORDS

Analgesia: postoperative, patient-controlled. Analgesics: morphine. Anaesthesia: paediatric.

Patient-controlled analgesia (PCA) has been used in children since 1987 [1], initially in adolescents and later in selected children as young as 5 yr [2–6]. The drug used most commonly has been morphine with a bolus dose of 10–25 μg kg^{-1} and a lockout interval of 5–15 min. A continuous background infusion has been used in some studies. These studies were empirical and there are few which have compared different PCA regimens in paediatric practice.

The addition of a background infusion to PCA may improve the quality of analgesia provided [7] by reducing the decrease in plasma concentrations of opioid during sleep. However, a fixed infusion may reduce the inherent safety of PCA by continuing to deliver opioid to a patient who has adequate analgesia [8]. The use of a background infusion may also result in larger amounts of opioid being administered and an increase in the incidence of opioid-induced side effects [9].

This study was carried out to assess the effect on postoperative analgesia, sedation, ventilatory frequency, nausea and vomiting, sleeping pattern and arterial oxygen saturation (Sp_{O_2}) of adding a background infusion of morphine to a PCA regimen in children.

PATIENTS AND METHODS

The study was approved by the hospital Ethics Committee and written informed parental consent was obtained. We studied 40 children aged 6–12 yr undergoing appendicectomy. The patients were visited before operation when the principles of using PCA were explained to the child and parents, and the patients were taught how to use the trigger of the PCA machine.

Patients were studied only if they had not received preoperative analgesia. All patients received a standard general anaesthetic which consisted of a rapid sequence induction with thiopentone 5–7 mg kg^{-1} and suxamethonium 1 mg kg^{-1}. The trachea was intubated and the patient's lungs ventilated with 67% nitrous oxide and 0.5–2% isoflurane in oxygen as indicated clinically. Neuromuscular paralysis was maintained with vecuronium 0.1 mg kg^{-1}. Morphine 0.1 mg kg^{-1} was given during operation. At the end of surgery, residual neuromuscular block was antagonized with neostigmine and glycopyrronium in appropriate doses. In the recovery area, patients were made comfortable by administration of increments of morphine 50 μg kg^{-1} if required.

Before patients left the recovery area, the PCA machine (Graseby PCAS or 3300) was connected. The solution used consisted of morphine sulphate 1 mg kg^{-1} diluted to 50 ml with 0.9% saline to give a concentration of 20 μg kg^{-1} ml^{-1}. The PCA machine was attached to the side arm of a Cardiff one-way valve incorporated into the i.v. infusion cannula. The settings used were a bolus dose of 1 ml (20 μg kg^{-1}) with a lockout interval of 5 min. Patients were allocated randomly (by means of a computer-generated list) to receive either this PCA regimen or the same PCA regimen with a background infusion of morphine 1 ml h^{-1} (20 μg kg^{-1} h^{-1}).

After operation, patients breathed air and a monitoring regimen described previously [10] was used: Sp_{O_2}, ventilatory frequency, sedation score, pain score and nausea score, the number of demands

E. DOYLE, F.R.C.A.; D. ROBINSON, F.R.C.A.; N. S. MORTON, F.R.C.A.; Department of Anaesthesia, Royal Hospital for Sick Children, Yorkhill, Glasgow G3 8SJ. Accepted for Publication: June 9, 1993.

Correspondence to E.D.

made and the volume of solution infused were recorded hourly. Patients were visited three times daily by one of the authors, when the correct use of the trigger was emphasized and syringes were replaced if necessary. A named anaesthetist was available to deal with any problems relating to the PCA regimens. The PCA was discontinued when there was a consistent decline in use and patients were able to take oral analgesics.

Pain was scored using a four-point self-reporting score which has been validated previously [11]: A = asleep; 0 = no pain; 1 = not really sore; 2 = quite sore; 3 = very sore. Children were not awakened for assessment unless the nurse suspected oversedation; "A" was recorded on the chart at these times.

Sedation was scored using a four-point scale: 0 = eyes open spontaneously; 1 = eyes open to speech; 2 = eyes open when shaken; 3 = unrousable.

Nausea was scored on a four-point scale: 0 = none; 1 = nausea only; 2 = vomited once in the past 1 h; 3 = vomited more than once in the past 1 h.

If there was a pain score of 3, a sedation score of 3 or a nausea sore of 3, the named anaesthetist was asked to see the patient.

Results were analysed using the Mann–Whitney U test and chi-square tests as appropriate.

RESULTS

Details of the patients are shown in table I.

The total morphine consumption in the PCA + background group was significantly ($P < 0.01$) greater than that in the PCA only group. There was no significant difference in the amounts of morphine self-administered in the two groups.

TABLE I. *Patient characteristics and details of morphine usage (number, mean (range or SD)).* * $P < 0.05$ *between groups*

	PCA only		PCA + background
Sex (M:F)	11:9		12:8
Age (yr)	9.6 (6–12)		10.2 (6–12)
Weight (kg)	33.5 (12.6)		32.8 (9.3)
Time of operation			
06:00–22:00	11		13
22:00–06:00	9		7
Duration of PCA (h)	36.9 (11.1)		37.1 (7.4)
Morphine usage			
($\mu g\ kg^{-1}$)	980 (434)	*	1635 (748)
($\mu g\ kg^{-1}\ h^{-1}$)	27.6 (12.7)	*	43.3 (14.8)
Background infusion ($\mu g\ kg^{-1}$)			694 (189)
PCA ($\mu g\ kg^{-1}$)	980 (434)		941 (718)

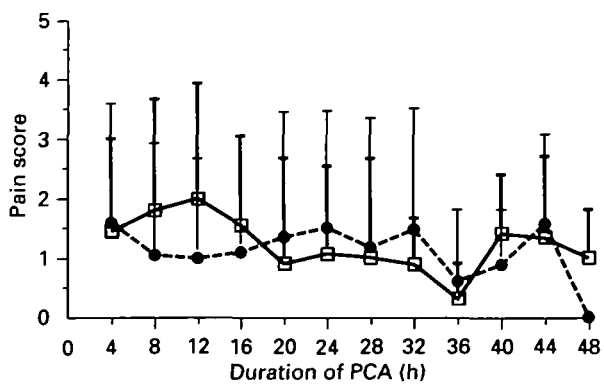

FIG. 1. Mean (SD) 4-hourly total pain scores in patients receiving PCA only (□) or PCA + background infusion (●).

For each patient, the hourly pain scores during each 4-h period were summed at 4-h intervals after the start of treatment and the means for patients in the two groups calculated (fig. 1).

There were no significant differences between the scores of the two groups in any of these periods.

There were significantly more instances of Sp_{O_2} less than 94% in the PCA + background group (143) than in the PCA only group (94) ($P < 0.001$). The smallest values of Sp_{O_2} recorded at any time (including those noted between hourly recordings) in the two groups were in the ranges 83–95% (mean 91%) in the PCA + background group and 88–94% (mean 92%) in the PCA only group.

Four occasions when ventilatory frequency was < 10 b.p.m. were noted in the same patient who was receiving a background infusion. Sp_{O_2} values at these times were 96%, 93%, 97% and 90%, respectively. The slowest ventilatory frequencies recorded in the two groups were 7–18 b.p.m. (mean 16 b.p.m.) in the PCA + background group and 12–20 b.p.m. (mean 17 b.p.m.) in the PCA only group.

The occurrence of sedation scores of 2 or greater were compared. There were no recordings of 3 in either group, but a significantly greater number of scores of 2 in the PCA + background infusion group (13) than in the PCA only group (4) ($P < 0.05$).

There was a significantly greater incidence of nausea and vomiting in the PCA + background group (37) than in the PCA only group (15) ($P < 0.01$). Antiemetics were given to one child in the PCA + background group.

The number of adverse events ($Sp_{O_2} < 94\%$, sedation scores ⩾ 2, nausea and vomiting) during the first 24 h of PCA use and subsequently did not differ between the groups.

The amount of time that patients in the two groups spent asleep was compared separately for the periods from 22:00 to 06:00 (night) and from 06:00 to 22:00 (day). Patients in the PCA + background group spent significantly ($P < 0.001$) more time asleep at night (198 h) than those in the PCA only group (154 h). There was no difference between the two groups in the time spent asleep during the day. Similar numbers of patients in both groups were operated on during the day and at night. The effect of the timing of operation on sleep pattern should, therefore, have been the same in both groups.

The analgesia provided in both groups was generally very good, with only 119 scores of 2 = quite sore or 3 = very sore from a total of 1521 scores (59 of 759 scores in the PCA only group and 60 of 762 in the PCA + background infusion group).

One child in the PCA + background group had the background infusion discontinued because of persistently decreased Sp_{O_2} when asleep, although the ventilation frequency was always 14 b.p.m. or greater.

DISCUSSION

Since its first use in children in 1987, PCA has become a widely used and effective treatment for

acute pain in selected children as young as 5 yr. Most reports of its use in children are, however, simply descriptive and there are few controlled studies which compare different regimens in terms of efficacy, dosage and adverse effects.

The use of a concurrent background infusion with PCA in adults is currently an area of debate in the literature. It has been shown to improve pain relief in two studies [12, 13]. In one of these [12], the use of a background infusion after abdominal hysterectomy not only improved analgesia but was associated with improved sleep patterns and increased patient satisfaction without an increase in opioid-induced side effects. The other study [13] found that the use of a background infusion improved analgesia but was associated with an increase in opioid-related side effects such as nausea and vomiting. Significant respiratory depression was not observed.

Other studies have shown no benefit when a background infusion was added to the PCA regimen [14–16]. In these patients, morphine consumption was increased with no improvement in analgesia. The incidence of side effects was not increased and respiratory depression was not noted in the group receiving a background infusion.

In paediatric practice, one study [17] has compared PCA with and without a background infusion (in a comparison with i.m. injections). In that study, the infusion used was morphine 15 $\mu g\ kg^{-1}\ h^{-1}$. The PCA only group received bolus doses of 25 $\mu g\ kg^{-1}$ and the PCA + background infusion group received bolus doses of morphine 18 $\mu g\ kg^{-1}$. In both groups, lockout time was 10 min. There were no differences in morphine consumption, sedation, nausea or vomiting between the groups. Respiratory depression was not noted in any patient. The PCA + background group was found to have smaller pain scores than the PCA only group. This study used patient and nursing visual analogue scores for pain assessment, whereas our study used a patient self-report scale; this may account for the different findings of the two studies. Another study [18] in children found that PCA + background infusion did not improve analgesia, but was associated with a better sleep pattern than PCA alone, with no increase in the incidence of side effects.

Our study has found that the use of a background infusion of morphine 20 $\mu g\ kg^{-1}\ h^{-1}$ in a PCA regimen for children undergoing lower abdominal surgery produced a significant increase in morphine consumption without improving pain relief, and a significant increase in the incidence of side effects (respiratory depression, over-sedation and nausea or vomiting). Patients in the PCA + background group spent more time asleep at night than those in the PCA only group. There was no suggestion that the incidence of side effects increased with the duration of PCA use as the severity of postoperative pain declined.

The great variability in the morphine requirements of our patients, who had all undergone the same operation, is shown by the large standard deviation in the amount of morphine self-administered. The use of a fixed dose of morphine to cope with this wide variability would be expected to be unsuccessful. This may be why the use of a relatively small fixed infusion in addition to the PCA produced no discernible improvement in analgesia.

This is the first study to have shown an increased incidence of respiratory depression in patients receiving a background infusion compared with those receiving PCA only. Respiratory depression has been considered to be one risk associated with the addition of an infusion to PCA, but has not previously been shown to occur. The reason for this is probably that the previous studies comparing PCA with and without a background infusion [12–17] and the descriptive publications of patients receiving PCA + background have relied on intermittent timing of ventilatory frequency as an indicator of respiratory depression. This has been shown to be a late and insensitive monitor of respiratory depression [19, 20]. Arterial oxygen saturation (Sa_{O_2}) while breathing air is a more sensitive monitor of adequate ventilation and it has been suggested that pulse oximetry should be routine for the monitoring of children receiving PCA [21]. An Sa_{O_2} of 94% corresponds to a Pa_{O_2} of 10 kPa in healthy patients and indicates mild hypoxia and reduced reserve should further respiratory depression occur.

The use of PCA in adults also is associated with an incidence of respiratory depression. This may occur in up to 40% of patients breathing air after upper abdominal surgery [22]. Patients using PCA after lower abdominal surgery have been shown to be more likely to suffer episodes of mild hypoxaemia than patients receiving i.m. or extradural morphine [23]. Other studies have shown no difference between the incidences of hypoxaemia in adults receiving PCA and those receiving i.m. morphine [22].

In our study, 15% of Sp_{O_2} values were less than 94% in the PCA only group. The significance of this is unclear as there is no information on the incidence of hypoxaemia detected by pulse oximetry in children breathing air and given i.m. opioids.

ACKNOWLEDGEMENT

Dr Doyle was supported by a grant from the Sir Jules Thorn Charitable Trust.

REFERENCES

1. Brown RE, Broadman LM. Patient controlled analgesia (PCA) for postoperative pain control in adolescents. *Anesthesia and Analgesia* 1987; **66**: S22.
2. Dodd E, Wang JM, Rauck RL. Patient-controlled analgesia for post-surgical pediatric patients aged 6–16 years. *Anesthesiology* 1988; **69**: A372.
3. Gaukroger PB, Tomkins DP, van der Walt JH. Patient-controlled analgesia in children. *Anaesthesia and Intensive Care* 1989; **17**: 264–268.
4. Broadman LM, Brown RE, Rice LJ, Higgins T, Vaughan M. Patient-controlled analgesia in children and adolescents: a report of postoperative pain management in 150 patients. *Anesthesiology* 1989; **71**: A1171.
5. Lawrie SC, Forbes DW, Akhtar TM, Morton NS. Patient-controlled analgesia in children. *Anaesthesia* 1990; **46**: 1074–1076.
6 Rodgers EM, Webb CJ, Stergios D, Newman BM. Patient-controlled analgesia in pediatric surgery. *Journal of Pediatric Surgery* 1988; **23**: 259–262.
7. Kay B. Postoperative pain relief. Use of an on-demand

analgesia computer (ODAC) and a comparison of the rate of use of fentanyl and alfentanil. *Anaesthesia* 1981; **36**: 949–951.
8. Owen H, Mathers LE, Rowley K. The development and clinical use of patient-controlled analgesia. *Anaesthesia and Intensive Care* 1988; **16**: 437–447.
9. McKenzie R. Patient-controlled analgesia (PCA). *Anesthesiology* 1988; **69**: 1027.
10. Morton NS. Development of a monitoring protocol for the safe use of opioids in children. *Paediatric Anaesthesia* 1993; **3**: 179–184.
11. Maunuksela E, Olkkola KT, Korpela R. Measurement of pain in children with self-reporting and behavioural assessment. *Clinical Pharmacology and Therapeutics* 1987; **42**: 137–141.
12. McKenzie R, Rudy T, Tantisira B. Comparison of PCA alone and PCA with continuous infusion on pain relief and quality of sleep. *Anesthesiology* 1990; **73**: A787.
13. Sinatra R, Chung KS, Silverman DG, Brull SJ, Chung J, Harrison DM, Donielson D, Weinstock A. An evaluation of morphine and oxymorphone administered via patient-controlled analgesia (PCA) or PCA plus basal infusion in postcesarean delivery patients. *Anesthesiology* 1989; **71**: 502–507.
14. Owen H, Szekely SM, Plummer JL, Cushnie JN, Mather LE. Variables of patient-controlled analgesia: 2. Concurrent infusion. *Anaesthesia* 1989; **44**: 11–13.
15. Wu MYC, Purcell GJ. Patient-controlled analgesia—the value of a background infusion. *Anaesthesia and Intensive Care* 1990; **18**: 575–576.
16. Parker RK, Holtmann B, White PF. Effects of a nighttime opioid infusion with PCA therapy on patient comfort and analgesic requirements after abdominal hysterectomy. *Anesthesiology* 1992; **76**: 362–367.
17. Berde CB, Lehn BM, Yee JD, Sethna NF, Russo D. Patient-controlled analgesia in children: a randomised prospective comparison with intramuscular administration of morphine for postoperative analgesia. *Journal of Pediatrics* 1991; **118**: 460–466.
18. Skues MA, Watson DM, O'Meara M, Goddard JM. Patient-controlled analgesia in children. A comparison of two infusion techniques. *Paediatric Anaesthesia* 1993; **3**: 223–228.
19. Wheatly RG, Somerville ID, Sapsford DJ, Jones JG. Postoperative hypoxaemia: comparison of extradural, i.m. and patient-controlled opioid analgesia. *British Journal of Anaesthesia* 1990; **64**: 267–275.
20. Catley DM, Thornton C, Jordan C, Lehane JR, Jones JG. Pronounced episodic oxygen desaturation in the postoperative period: its association with ventilatory pattern and analgesic regime. *Anesthesiology* 1985; **63**: 20–28.
21. Morton NS, Gillespie JA. Safety of PCA in children. The role of pulse oximetry. *Journal of Pain and Symptom Management* 1991; **6**: 142.
22. Wheatly RG, Shepherd D, Jackson IJB, Madej TJ, Hunter D. Hypoxaemia and pain relief after upper abdominal surgery: comparison of i.m. and patient-controlled analgesia. *British Journal of Anaesthesia* 1992; **69**: 558–561.
23. Brose WB, Powar M, Cohen SE. Oxygen saturation in post Cesarean patients using epidural morphine, PCA or i.m. narcotic analgesia. *Anesthesia and Analgesia* 1988; **67**: S24.