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PATIENT-CONTROLLED ANALGESIA WITH LOW DOSE BACKGROUND INFUSIONS AFTER LOWER ABDOMINAL SURGERY IN CHILDREN

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SUMMARY

Forty-five children (aged 6–12 yr) undergoing appendicectomy received one of three analgesic regimens using patient-controlled analgesia (PCA) with morphine: no background infusion (B0); background infusion 4 μg kg^{-1} h^{-1} (B4); background infusion 10 μg kg^{-1} h^{-1} (B10). Total consumption of morphine was greater in group B10 compared with groups B0 (P < 0.01) and B4 (P < 0.05). There was no significant difference in morphine consumption in groups B0 and B4. All three groups self-administered similar amounts of morphine and there were no significant differences in pain scores or incidence of excessive sedation. Group B4 suffered less hypoxaemia compared with groups B0 (P < 0.01) and B10 (P < 0.001). Group B10 suffered more nausea and vomiting than groups B0 (P < 0.001) and B4 (P < 0.001), but there was no significant difference in the incidence of nausea and vomiting between groups B0 and B4. Groups B4 and B10 spent more time at night asleep than group B0 (P < 0.05). There were no significant differences between the groups in the amount of time spent asleep during the day. Inclusion of a background infusion of morphine 4 μg kg^{-1} h^{-1} in a PCA regimen for children did not increase the incidence of side effects and was associated with less hypoxaemia and a better sleep pattern than no background infusion. (Br. J. Anaesth. 1993; **71**: 818–822)

KEY WORDS

Analgesia: patient-controlled. Vomiting, nausea.

Patient-controlled analgesia (PCA) is now used in children as young as 5 yr for the treatment of postoperative pain [1]. The drug used most commonly is morphine, in a bolus dose of 10–25 μg kg^{-1} and a lockout interval of 5–15 min. These settings are empirical and there are few well conducted studies which have compared different PCA regimens in paediatric practice. In particular, the benefits and risks of background infusions have not been defined. Adult studies give conflicting results [2–6] and one study in children [7] found an improvement in analgesia without an increase in side effects with a background infusion of morphine 15 μg kg^{-1} h^{-1}. A more recent paediatric study [8] found that a background infusion of morphine 20 μg kg^{-1} h^{-1} did not improve pain scores, but was associated with a better sleep pattern. However, the background infusion was associated with a greater incidence of hypoxaemia, excessive sedation, nausea and vomiting compared with the PCA-only regimen.

This study was carried out to assess the effect of two different low-dose background infusions on postoperative analgesia, sleep pattern, morphine consumption, sedation, nausea, vomiting, respiratory depression and arterial oxygen saturation in air (Sp_{O_2}).

PATIENTS AND METHODS

The study was approved by the hospital Ethics Committee and written informed parental consent was obtained. On the basis of previous work using this methodology [8], it was calculated that this study had a 90% probability of detecting differences between groups which would be significant at the 5% level. Forty-five children aged 6–12 yr undergoing appendicectomy were recruited. Patients were visited before operation, when the principles of using PCA were explained to the child and parents. Patients were taught to use the trigger of the PCA machine during this visit. Patients were not studied if they had received preoperative analgesia.

All patients received a standard general anaesthetic which comprised 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 0.5–2.0% isoflurane in oxygen as indicated clinically. Neuromuscular block was maintained with vecuronium 0.1 mg kg^{-1}. Morphine 0.1 mg kg^{-1} was given during operation. At the end of surgery, neuromuscular block was antagonized with neostigmine and glycopyrronium in appropriate doses. In the recovery area, patients were made comfortable with boluses of morphine 50 μg kg^{-1} if required.

Before the patient left the recovery area, the PCA pump was set up (Graseby PCAS and Graseby 3300). The solution consisted of morphine 1 mg kg^{-1}

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TABLE I. *Patient characteristics and details of morphine consumption (mean (range or SD)). Significant differences compared with group B10: *P < 0.05; **P < 0.01*

	Group B0	Group B4	Group B10
Sex (M:F)	7:8	8:7	10:5
Age (yr)	10.5 (8.7–12.1)	10.4 (6.5–12.9)	10.3 (7.2–12.4)
Weight (kg)	35.5 (9.0)	35.9 (6.8)	40.0 (10.7)
Time of operation			
06:00–22:00	10	9	10
22:00–06:00	5	6	5
Duration of PCA use (h)	38.5 (5.2)	42.7 (9.5)	45.4 (12.6)
Total morphine consumption			
($\mu g\ kg^{-1}$)	880 (389)**	1080 (467)*	1524 (619)
($\mu g\ kg^{-1}\ h^{-1}$)	23.5 (10.8)**	25.4 (9.2)*	35.9 (18.9)
Self-administered morphine			
($\mu g\ kg^{-1}$)	880 (389)	910 (452)	1062 (638)
($\mu g\ kg^{-1}\ h^{-1}$)	23.5 (10.8)	21.4 (9.2)	25.9 (18.9)

diluted to 50 ml with 0.9% saline (20 $\mu g\ kg^{-1}\ ml^{-1}$). The PCA machine was attached to the side arm of a Cardiff one-way valve incorporated into the i.v. infusion cannula. Patients were allocated randomly (computer-generated list) to receive one of three different PCA regimens: group B0 received bolus doses of morphine 20 $\mu g\ kg^{-1}$ with a lockout interval of 5 min and no background infusion; group B4 received bolus doses of 20 $\mu g\ kg^{-1}$ with a lockout interval of 5 min and a background infusion of morphine 4 $\mu g\ kg^{-1}\ h^{-1}$; group B10 received bolus doses of 20 $\mu g\ kg^{-1}$ with a lockout interval of 5 min and a background infusion of 10 $\mu g\ kg^{-1}\ h^{-1}$.

After operation, patients breathed air and a monitoring regimen described previously [9] was used. This involved a high dependency level of nursing care with hourly recordings of Sp_{O_2}, ventilatory frequency and sedation, pain and nausea scores. The number of demands made and the volume of solution infused were also recorded hourly. Patients were reviewed regularly by one of the authors. There was always a named anaesthetist available to deal with any problems relating to the PCA regimen. PCA was discontinued when there was a consistent decline in use and the patient was able to take oral analgesics.

Pain was measured using a four-point, self-reporting score which has been validated previously [10]: 0 = no pain; 1 = not really sore; 2 = quite sore; 3 = very sore.

Children were not awakened from sleep for assessment unless the nurse suspected excessive sedation and "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.

We considered patients to be sedated excessively if they were not rousable by speech and required to be shaken. Experienced paediatric nurses were able to differentiate between a child who was asleep naturally and one who was sedated excessively as a result of opioid.

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 score of 3, the named anaesthetist was asked to see the patient.

Results were analysed using analysis of variance and the Mann–Whitney *U* test for pain scores and morphine consumption, and chi-square tests for comparisons of events between groups.

RESULTS

Patient characteristics are shown in table I.

Two patients in group B0, one in group B4 and one in group B10 received a bolus of morphine 50 $\mu g\ kg^{-1}$ in the recovery area. These boluses were not included in the figures for postoperative consumption of morphine.

Patients in all three groups self-administered similar amounts of morphine using the PCA machine. Total morphine consumption was significantly greater in group B10 compared with groups B0 ($P < 0.01$) and B4 ($P < 0.05$). Group B4 self-administered 2 $\mu g\ kg^{-1}\ h^{-1}$ less than group B0; thus when the background infusion is taken into account, group B4 received 2 $\mu g\ kg^{-1}\ h^{-1}$ more morphine than group B0.

For each patient, the hourly pain scores during each 4-h period after the start of the PCA regimen were totalled. The mean 4-hourly totals for patients in the three groups are shown in figure 1. There were no significant differences between the scores of the three groups during any of these periods.

Table II shows the numbers of patients in each group who were receiving PCA at the end of each 12-h period after operation.

Sp_{O_2} readings were accepted as valid and recorded only if they were consistent over 2–3 min and there was a good pulse signal on the oximeter screen. The occurrence of hypoxaemic episodes (defined as $Sp_{O_2} < 94\%$) in the three groups is shown in table III. Group B10 had significantly more recordings less than 94% compared with groups B0 ($P < 0.001$) and B4 ($P < 0.001$). Group B0 had significantly more recordings less than 94% compared with group B4 ($P < 0.01$). The smallest Sp_{O_2} values in the three groups were 86–95% (mean 91.6%) in group B0, 86–95% (mean 92.4%) in group B4 and 86–95% (mean 90.3%) in group B10.

The slowest ventilatory frequencies recorded in the three groups were 12–18 b.p.m. in group B0, 12–20 b.p.m. in group B4 and 14–18 b.p.m. in group B10.

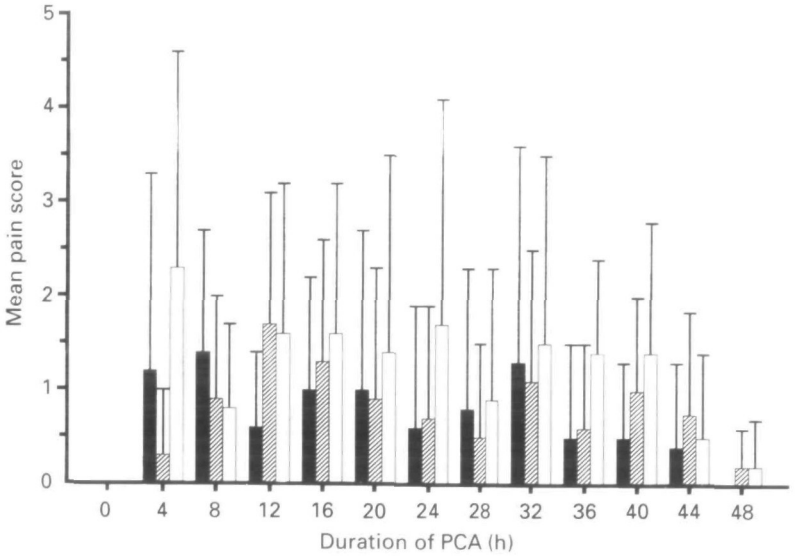

FIG. 1. Mean (SD) 4-hourly total pain scores in groups B0 (■), B4 (▨) and B10 (□).

TABLE II. *Numbers of patients in each group using PCA after each 12-h interval after operation*

	Group B0	Group B4	Group B10
12 h	15	15	15
24 h	15	15	15
36 h	13	13	14
48 h	2	4	3

TABLE III. *Comparison of incidence of Sp_{O_2} readings less than 94% in the three groups. **Significantly greater than group B4 ($P < 0.01$, $\chi^2 = 6.9$); ***significantly greater than B0 and B4 ($P < 0.001$, $\chi^2 = 51$)*

	Group B0	Group B4	Group B10
$Sp_{O_2} < 94\%$	78**	56	159***
$Sp_{O_2} \geq 94\%$	499	583	523

TABLE IV. *Comparison of the incidence of emetic sequelae in the three groups. ***Significant difference ($P < 0.001$) compared with groups B0 ($\chi^2 = 16.2$) and B4 ($\chi^2 = 14.9$)*

	Group B0	Group B4	Group B10
Episodes of emetic sequelae	20	22	60***
No. of patients who complained of emetic sequelae	8	8	10

TABLE V. *Comparison of duration of sleep between 22:00 and 06:00 (night) and between 06:00 and 22:00 (day) in the three groups. *Significant difference ($P < 0.05$) compared with groups B4 ($\chi^2 = 5.3$) and B10 ($\chi^2 = 5.3$)*

	Group B0	Group B4	Group B10
Night			
Asleep	142*	178	217
Awake	78	61	68
Day			
Asleep	85	92	86
Awake	272	308	311

A sedation score of 3 was not recorded in any patient. A sedation score of 2 occurred on 22 occasions in group B0, 19 in group B4 and on 21 occasions in group B10 (not significant).

Group B10 suffered significantly more emetic sequelae than groups B0 ($P < 0.001$) and B4 ($P < 0.001$) (table IV). There was no significant difference in the incidence of emetic sequelae between groups B0 and B4. Antiemetics were given to one patient in group B10.

The amount of time spent asleep was compared in the three groups by analysing the periods from 22:00 (after the evening ward drug round) to 06:00 (night) and from 06:00 to 22:00 (day) separately. Groups B4 and B10 spent significantly more time asleep at night compared with patients in group B0 ($P < 0.05$). There was no significant difference between groups B4 and B10 in the amount of time spent asleep at night, and no significant differences between the groups in the amount of time spent asleep during the day (table V). Similar numbers of patients in all groups were operated upon during the day and at night.

Three patients in group B10 had the background infusion discontinued because of persistent excessive sedation.

DISCUSSION

There are few controlled studies which have compared different PCA regimens for children in terms of efficacy, dosage and adverse effects. The role for a background infusion with PCA has not been defined clearly. The perceived advantage of using a background infusion is that it improves continuity of analgesia and provides analgesia during sleep. This may improve sleep patterns in postoperative patients by reducing the number of occasions when patients are wakened by pain which requires subsequent use of the PCA device for relief.

The operation of appendicectomy provides a good model for the study of postoperative analgesic regimens. It involves a standard surgical procedure and a degree of peritoneal irritation which ensures

that postoperative morphine requirements when self-administered with a PCA machine are of the order of 20–30 μg kg^{-1} h^{-1}, which is the same as that in children after more major abdominal and orthopaedic surgery [11–14].

This study has shown that the use of a background infusion of morphine 4 μg kg^{-1} h^{-1} in a PCA regimen for children after lower abdominal surgery caused no increase in side effects compared with no background infusion and was associated with less hypoxaemia and a better sleep pattern than PCA only. A background infusion of morphine 10 μg kg^{-1} h^{-1} was associated with a better sleep pattern also, but was accompanied by a significant increase in the incidence of hypoxaemia and nausea and vomiting. Unlike a background infusion of 20 μg kg^{-1} h^{-1} [8], these smaller infusion rates were not associated with an increase in the incidence of excess sedation.

The reason why a background infusion of morphine 4 μg kg^{-1} h^{-1} produces less hypoxaemia than a PCA regimen with no background infusion may be that the infusion produced better analgesia and improved ventilation. This suggests that the method for assessing pain used in this study (patient self-report) is relatively insensitive. A specific assessment of pain on moving or coughing may have revealed differences in analgesia between groups B0, B4 and B10. We have also previously noted that periods of hypoxaemia often correspond with high pain scores [9].

In adult studies, the use of a background infusion has been shown to improve pain relief in two studies [2, 3], but not in others [4–6]. The studies which found no benefit from a background infusion did not assess pain during movement. In contrast, one of the studies which did find improved analgesia with a background infusion [3] did assess pain on movement. The other study [2] did not make clear if pain was assessed only at rest or during movement. Two studies [3, 5] found an increase in opioid-induced side effects (other than respiratory depression) with a background infusion. The size of background infusion of morphine varied from 0.6 mg h^{-1} to 1.5 mg h^{-1} (pethidine 10 mg h^{-1} in one), which is equivalent to 10–20 μg kg^{-1} h^{-1}.

In paediatric practice, two studies [7, 8] have compared PCA with and without a background infusion. In one [7] the infusion used was morphine 15 μg kg^{-1} h^{-1} and there were no differences in morphine consumption, sedation, nausea or vomiting. Respiratory depression (as measured by ventilatory frequency) was not noted in any patient. The PCA plus background infusion group were found to have smaller pain scores than the PCA only group as assessed by patient and nurse visual analogue scales.

In the other study [8], a background infusion of morphine 20 μg kg^{-1} h^{-1} produced a significant increase in morphine consumption without improving pain scores (assessed by patient self-report). There was also a significant increase in the incidence of opioid-induced side effects (respiratory depression, excessive sedation, nausea and vomiting) in the background infusion group. However, the use of a background infusion was associated with a better sleep pattern.

Opioid-induced respiratory depression has been considered to be a risk of background infusion, but has been shown to occur only in one paediatric study [8] when Sp_{O_2} was measured continuously with patients breathing air. Intermittent recording of ventilatory frequency has been shown to be an insensitive monitor of opioid-induced respiratory depression in adults [15–17]. Studies which have relied on intermittent recording of ventilator frequency as an indicator of respiratory depression and have concluded that a background infusion does not produce respiratory depression [2–7] may be falsely optimistic. Arterial oxygen saturation while breathing air is a more sensitive monitor of adequate ventilation. Sp_{O_2} 94% corresponds to an arterial oxygen tension of 10 kPa and indicates mild hypoxaemia. In the absence of other causes of hypoxaemia, this indicates a degree of ventilatory depression which may be caused by opioid administration or pain. In our experience, pain is a more common reason for hypoxaemia than opioid overdosage. This emphasizes the need for careful and repeated assessments by experienced staff.

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