

Patient-controlled analgesia after spinal fusion for idiopathic scoliosis

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Summary. *One hundred adolescents undergoing posterior spinal fusion for scoliosis were reviewed to assess the adequacy of postoperative patient-controlled analgesia. There were 94 females and 6 males. The mean settings for morphine dosage were a loading dose of 114.5 $\mu\text{g} \cdot \text{kg}^{-1}$, a bolus dose of 24.8 $\mu\text{g} \cdot \text{kg}^{-1}$, and a lockout interval of 9.9 minutes. This was used for an average of 75.8 h, with a 52.2% success rate. Adolescents using patient-controlled analgesia showed a great variability in morphine requirements with greater use as they became older. The requirement was not significantly different on the 1st, 2nd and 3rd postoperative days and the total consumption was 52.2 $\mu\text{g} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$. Nausea and vomiting occurred in 45% and pruritus in 15%. There were 7 cases of respiratory depression who all recovered promptly and completely. This method is associated with high morphine requirements in adolescents, but can be used safely.*

Résumé. *Nous avons étudié rétrospectivement l'utilisation de l'analgésie contrôlée par le patient (ACP) chez 100 adolescents ayant subi une chirurgie de correction de scoliose idiopathique. Quatre-vingt-quatorze adolescentes et 6 adolescents, de 11 à 19 ans, ont été inclus dans cette étude. La programmation de la pompe d'ACP pour la morphine était la suivante: dose de charge 114.5 $\mu\text{g} \cdot \text{kg}^{-1}$, bolus de 24.8 $\mu\text{g} \cdot \text{kg}^{-1}$ et intervalle entre deux injections de 9.9 minutes. L'ACP a été utilisée en moyenne pendant 75.8 heures, et le pourcentage de demandes satisfaites était de 52.2. Les besoins en morphine délivrée par l'ACP, ont*

été très variables, avec une tendance vers des besoins plus importants avec l'âge. Les besoins en morphine n'ont pas été significativement différents durant les trois premiers jours postopératoires, et la consommation moyenne de morphine pendant cette période a été de 52.5 $\mu\text{g} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$. Les nausées et vomissements ont été rapportés chez 45% des adolescents, contre 15% pour le prurit. Nous avons enregistré 7 cas de dépression respiratoire, mais tous les patients ont récupéré rapidement et complètement. L'utilisation de l'ACP chez l'adolescent après chirurgie orthopédique majeure est associée à des besoins importants en morphine, mais reste sécuritaire.

Introduction

Patient-controlled analgesia (PCA) is a safe and effective way of relieving postoperative pain [22] and has been used in adolescents after various surgical procedures. There is, however, wide variation in the doses of opioid required in the heterogeneous groups reported [9, 19].

The objectives of this review were to determine the safety of PCA in adolescents after major orthopaedic operations, to record the opioid requirements and problems at this age and to identify means of improving our practice.

Patients and methods

We reviewed 100 consecutive posterior spinal fusions with Cotrel-Dubousset instrumentation over 3 years from May 1991

Table 1. Patients' data ($n = 100$)

Age (years)	14.4	(1.8)	11– 19
Gender			
Female	94		
Male	6		
Weight (kg)	52.2	(10.1)	31– 99
Height (cm)	162.6	(7.9)	138–185
Angle of scoliosis (°)	55.3	(12.5)	25–105
Number of vertebrae instrumented	11.1	(1.8)	5– 15
Operating room time (h)	6.5	(0.9)	4.4– 9.5
Haemoglobin ($\text{g} \cdot \text{l}^{-1}$)	85.4	(12.9)	56–117
Recovery room PCA discontinuation	86.7	(10.3)	59–110

Values are expressed as mean (SD) and range, except for gender

Table 2. PCA data

Analgesia peroperatively ($\mu\text{g} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$)			
Fentanyl ($n = 78$)	2.65	(1.0)	0.58– 5.4
Sufentanil ($n = 22$)	0.41	(0.18)	0.17– 0.89
Morphine in recovery room ($\mu\text{g} \cdot \text{kg}^{-1}$)	114.5	(75.24)	0 –360
Time to start of the PCA (min)	55.9	(51.4)	0 –235
Initial dose of morphine ($\mu\text{g} \cdot \text{kg}^{-1}$)	24.8	(4.3)	9.6 – 34.5
Lockout interval (min)	9.9	(0.45)	7 – 10
Duration of the PCA (h)	75.8	(20.9)	19 –160
Percentage of successful attempts	52.2	(17.6)	11.5 –100
Morphine requirements ($\mu\text{g} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$)	50.6	(20.0)	14.5 –104.6
0–24 h ($n = 99$)			
24–48 h ($n = 95$)	53.7	(21.7)	16.6 –107.7
48–72 h ($n = 80$)	50.2	(17.3)	9.0 –116.8
total ($n = 99$)	52.2	(18.2)	17.1 –101.3

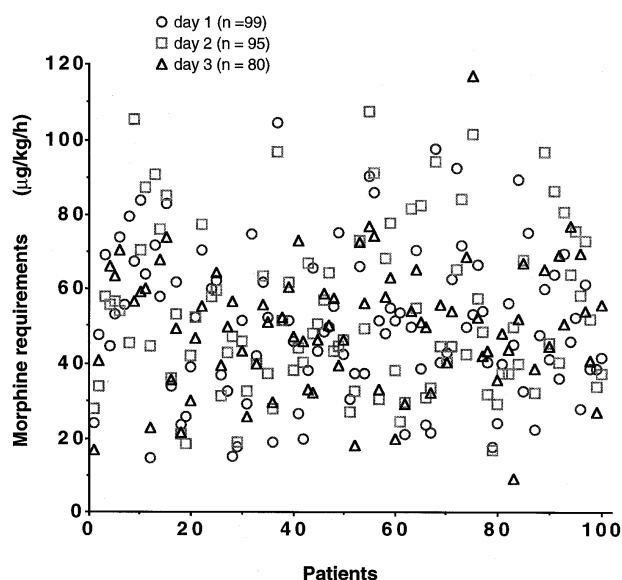
Values are expressed as mean (SD) and range

NB: pethidine requirements for the first three days were 109.05, 126.73 and 94.31 $\mu\text{g} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$ respectively (one patient)

to April 1994. The patients were adolescents with idiopathic scoliosis who used the PCA device after the operation. Their mean age was 14.4 years (range 11 to 19 years); 94 were female and 6 male. Their details are given in Table 1. Those with scoliosis of other aetiology and those who needed an anterior approach were excluded.

Instruction in the use of PCA was given to the patient by an anaesthetist before the operation. The anaesthetic technique was similar in all cases and based on balanced anaesthesia with intravenous opioids (fentanyl or sufentanil), a halogenated agent (isoflurane or halothane) and a muscle relaxant. A urinary catheter and a nasogastric tube were inserted after induction. Every patient underwent a wake-up test. PCA (infuser model 310, from IVAC® Corporation, San Diego, Ca) using morphine ($1 \text{ mg} \cdot \text{ml}^{-1}$) or pethidine ($10 \text{ mg} \cdot \text{ml}^{-1}$) was started in the recovery room where the patients received loading doses of the opioid until they reported adequate analgesia.

Details of the patients, their operative records and other important data were recorded, but their pain scores were not adequate for analysis. Specific data from the PCA charts

**Fig. 1.** Individual morphine requirements in $\mu\text{g} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$ when using PCA during the first 3 postoperative days

included the amount of opioid received as loading doses and during the first 3 postoperative days, the initial PCA settings and eventual modifications, the number of total and successful attempts, the duration of PCA and any side effects or complications.

Statistical analysis.

Comparisons between means were performed using analysis of variance (ANOVA) for repeated measures. Linear and multiple regression analysis were used to test a possible influence of age, sex, number of vertebrae instrumented or iliac bone grafting on morphine requirements. Values are expressed as mean (SD) and $P < 0.05$ was considered significant.

Results

The amount of opioid administered at operation, the amount of morphine given in the recovery room and data concerning PCA are given in Table 2.

All the patients used PCA with morphine, except for one who used pethidine. The dose had to be adjusted in 35% of the cases and the lockout interval in 11%; 10 needed 2 modifications of their regime and 2 others needed 4 adjustments. These changes occurred either because of inadequate pain relief or morphine side effects. Morphine was replaced by pethidine in 5 patients and by hydro-morphone in 2 because of persistent side effects with pruritus in 5, and nausea and vomiting in 2.

The hourly requirements of morphine used in the first 3 days after operation are shown in Table 2. No significant difference was found during the

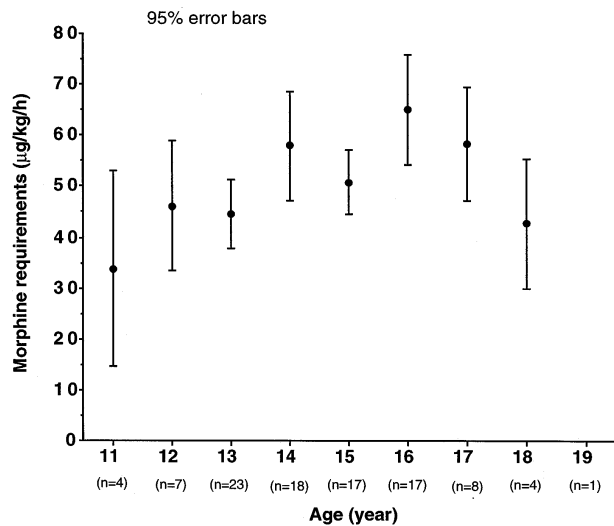


Fig. 2. The average morphine requirements in $\mu\text{g} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$ during total duration of the use of PCA for each age group. The 95% error bars are shown

first, second and third postoperative days (Fig. 1) between males and females, on taking into account the number of vertebrae instrumented or of the amount of iliac graft removed. Age was the only factor to determine variability ($p < 0.01$) with a tendency to greater use of morphine with increasing age (Fig. 2). The extremes were a 13 year old girl who made 33 attempts (lockout interval 10 min) 85% of which were successful over 43 h, whereas a 16 year old girl made 1261 attempts over 160 h with 36.4% successful tries (the lockout interval remained at 10 min, but morphine was changed to hydromorphone). One patient had a 100% score of successful attempts while using PCA for 64 h with the same 10 min interval.

The adverse effects of PCA are shown in Table 3. Among the 45 patients who complained of nausea and vomiting, 41 were treated with metoclopramide, supplemented by dimenhydrinate in 2 cases. Of the 15 patients with pruritus, 4 did not need any medication, 6 were treated with diphenhydramine, 3 with low doses of naloxone and 2 were given both drugs. Urinary retention occurred in 11 patients after removal of the catheter.

Respiratory depression was recorded in 7 patients, all of whom had received opioids using PCA, occurring in 5 between 4 and 30 hours after starting. One needed intravenous naloxone; the other 4 were prescribed changes in their PCA settings and/or supplementary oxygen. In 2 cases the respiratory depression occurred in the recovery room and the patients had to be re-intubated, ventilated and transferred to the intensive care

Table 3. Adverse effects associated with PCA

Nausea and vomiting	45 %
Pruritus	15 %
Urinary retention	11 %
Respiratory depression (RR < 10)	7 %
Somnolence	3 %
Time to first oral intake (h)	36.7 (15.8)
Time to removal of the urinary catheter (days)	3.5 (0.8)
Intensive Care Unit admission	
patients	9 %
duration of stay (h)	26.8 (12.4)

Values are expressed as mean (SD) except those indicated in %. RR = respiratory rate

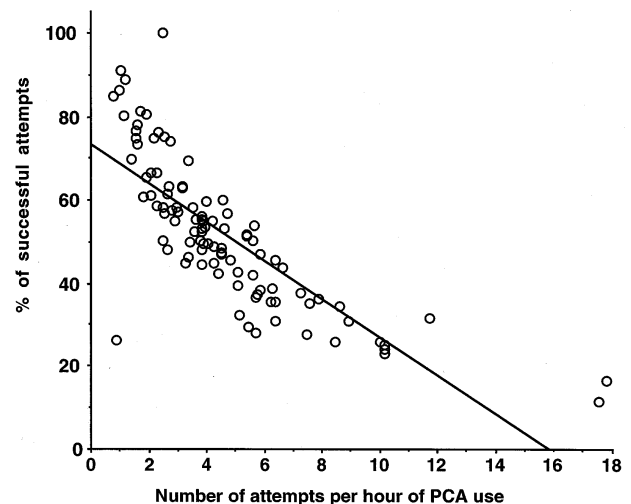


Fig. 3. The percentage of successful attempts for each patient is plotted against the total number of attempts per hour while using PCA, ($n = 100$, $p < 0.0001$)

unit. One had received a single dose of fentanyl $5 \mu\text{g} \cdot \text{kg}^{-1}$ caudally at the end of the operation.

A further 7 patients (9 in all) were admitted to the paediatric intensive care unit after leaving the recovery room; one had an epidural catheter in situ which was used until the next day, another had had cardiac surgery previously, and one suffered from slight mental retardation. This patient had his PCA stopped after 19 h because of his lack of understanding. Four other patients remained intubated at the end of the operation in order to decrease postoperative bleeding in 2, because of acute pulmonary oedema in one and in the other because of an air embolism during blood transfusion near the end of the operation. Five of the 9 who were kept in intensive care received fentanyl or morphine for analgesia and midazolam or diazepam for sedation before the PCA was started.

Patients pressed the PCA button on average 338 times (range 33 to 1261) during a mean duration of use of just over 3 days. Only 52.2% attempts were

followed by the delivery of an opioid bolus (Fig. 3). The patients were given a combination of paracetamol and codeine orally when PCA was discontinued.

Discussion

Most paediatric studies show wide variations in various factors relevant to the use of PCA, and we concentrated on adolescents undergoing spinal fusion for idiopathic scoliosis so that the surgical stimulus was standardised.

Morphine requirements

PCA provides satisfactory postoperative analgesia for adolescents [3, 19], but this age group showed great variability in their morphine requirements [3, 9], even in apparently similar cases [13]. Gaukroger has shown that more morphine is needed after operations for scoliosis; 11 patients undergoing Cotrel-Dubousset instrumentation required $53.1 \mu\text{g} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$ (19.1), compared with 29 patients having other orthopaedic or surgical procedures who required 33 to $36 \mu\text{g} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$ (18.2) [9]. Other studies of from one to 21 patients after scoliosis operations reported values from 24 to $40 \mu\text{g} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$ [10, 16, 19, 21].

PCA settings and use

The mean initial bolus dose was $24.8 \mu\text{g} \cdot \text{kg}^{-1}$ with a lockout interval of nearly 10 min which is in accordance with the guidelines for PCA in children for the initial pump settings ($20 \mu\text{g} \cdot \text{kg}^{-1} \cdot \text{h}$ with 5 to 10 min) [11]. The high number of adjustments, either up or down, of the bolus dose (in 35% of cases) or lockout interval (11%) emphasised the variability between patients. This is more than the 12.5% changes reported by others [9].

The low percentage of successful attempts (52.2%) further stresses the variability in morphine requirements. The psychological status of these adolescents and their parents can significantly influence postoperative pain and the need for PCA [10]. The 10 minute lockout interval used in 95% may have been too long and this could have contributed to unsuccessful attempts. Recent studies have been using lockout intervals of 5 or 6 min in children [7, 18].

The mean duration of PCA in our patients was 3.1 days, but other studies of general, orthopaedic and thoracic operations used PCA for 1.1 to 2.6 days [9, 13, 14, 15, 16, 17, 20].

Respiratory depression

Our incidence of 7% was relatively high; the incidence has been recorded by others as between 0 and 1.1% [3, 9, 14, 18, 19]. A 25% incidence has, however, been reported in 2 groups of 20 patients (one having epidural analgesia and the other PCA) after orthopaedic operations; the mean requirement of morphine was $57.35 \mu\text{g} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$ in the PCA group [12]. None of these patients suffered from severe respiratory insufficiency or apnoeic episodes.

This complication causes concern and cannot be adequately assessed by counting the respiratory rate. Pulse oximetry and sedation scores increase the safety of PCA [6, 15].

Nausea and vomiting

Our 45% incidence is high, but not surprising because of the large doses of morphine used after operation. An incidence of between 21% for nausea and 33% for vomiting have been reported with morphine requirements between 33.6 and $53.1 \mu\text{g} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$ [9]. These side effects are difficult to compare because of the different factors involved including age, type of operation, presence of a nasogastric tube and opioid requirements. Patients do not always titrate themselves to complete analgesia and the occurrence of side effects is one of the reasons why this is so.

Pruritus

The 15% incidence in our series is the same as in a group of 20 patients with a mean age of 11.7 years who underwent osteotomies and who had a median dose of morphine of $57.3 \mu\text{g} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$ [12]. Vetter assessed prospectively the difference in either analgesia or frequency of side effects when using morphine compared with pethidine after orthopaedic operations, excluding posterior spinal fusion [20]. He found that although nausea and vomiting were more common with pethidine (40% v 28%), pruritus was more common with morphine (20% v 12%), but there was no statistically significant differences in the frequency of these side effects in the 2 groups.

Urinary retention

All our patients were catheterised after induction of anaesthesia and the catheter was removed an average of 8 h after PCA was discontinued. We found that removing the catheter while PCA was in use led to a large number of cases of retention. In spite of retaining the catheter for longer, 11 patients

complained of retention after their catheter was removed and needed it re-inserted. The discomfort and risk of infection while the catheter is in place have to be balanced against the risk of retention after its removal.

To improve our practice, we need to decrease the lockout interval in order to reduce the number of unsuccessful attempts and provide greater satisfaction to the adolescent. Furthermore, as well as continuing close monitoring of the patients, charting of pain scores is essential. The value of PCA in adolescents undergoing major orthopaedic surgery should lead to the same conclusions as in adults where it has been associated with better pain relief without an increase of side effects [1].

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