Comparison of i.v. and s.c. diamorphine infusions for the treatment of acute pain in children

D. Semple, L. A. Aldridge and E. Doyle

Summary
We have compared the i.v. and s.c. routes of administration for diamorphine infusions in children undergoing abdominal surgery. Subjects received general anaesthesia with extradural block and diamorphine up to 20 μg kg⁻¹ h⁻¹ after operation. There were no differences between the groups in diamorphine consumption, pain scores or incidence of side effects. The s.c. route appeared to be as effective and safe as the i.v. route for administration of diamorphine infusions in children undergoing elective surgery. (Br. J. Anaesth. 1996; 76: 310–312)

Key words
Analgesia, paediatric. Analgesic techniques, i.v. Analgesic techniques, s.c. Analgesics opioid, diamorphine. Pain, postoperative.

The use of i.v. opioid infusions to treat postoperative pain in children is a common and effective analgesic technique [1]. It requires a dedicated i.v. cannula for opioid administration in addition to one for i.v. fluids and drugs. Alternatively, the same cannula may be used for both fluids and opioid administration if an antireflux valve is used. The option of a second i.v. cannula is not always available, particularly in infants, while antireflux valves are expensive and make the infusion site bulky and difficult to nurse.

An alternative route of administration for opioid infusions which does not have these disadvantages is the s.c. route. This is used extensively in terminal and chronic pain and has also been described for the management of acute pain in adults [2]. The efficacy of s.c. infusions in children has been demonstrated recently [3]. For this technique to become widespread and accepted it must be shown to be as effective as the i.v. route with the same or a lower incidence of side effects. The i.v. and s.c. routes of administration have not been compared in children. This study was designed to compare these two routes in children undergoing abdominal surgery. On the basis of previous work using similar methodology [4] the power calculated for the study was that it would have a 90% chance of detecting differences between the groups which were significant at the 5% level.

Methods and results
The study was approved by the local Ethics Committee and written informed parental consent was obtained for each subject. We studied 30 children, aged 6 months to 11 yr, undergoing abdominal surgery. Exclusion criteria included contraindications to extradural block, significant hepatic or renal impairment, and significant mental handicap making assessment of pain difficult. Patients were premedicated with EMLA cream and anaesthesia was induced with propofol 3–4 mg kg⁻¹ and atracurium 0.5 mg kg⁻¹. After tracheal intubation, the lungs were ventilated with 0.5–2% halothane and 70% nitrous oxide in oxygen. Patients were then turned to the right lateral position and an extradural catheter placed at an appropriate dermatomal level for the proposed surgery. Extradural block was provided with 0.25% bupivacaine 1 ml kg⁻¹ with adrenaline 1/200 000 (maximum 20 ml) in divided doses. At the end of surgery, neuromuscular block was antagonized and the trachea extubated.

Patients were allocated randomly to receive either an i.v. or an s.c. infusion of diamorphine after operation. In the i.v. group (group IV), a second 22-gauge cannula was sited on the same side as the cannula used for induction. In the s.c. group (group SC), a 22-gauge cannula was sited s.c. over the deltoid muscle on the same side as the i.v. cannula.

In group IV the solution used consisted of diamorphine 1 mg kg⁻¹ diluted in 50 ml of 0.9% saline to give a concentration of 20 μg kg⁻¹ ml⁻¹. This was commenced at a rate of 1 ml h⁻¹ (20 μg kg⁻¹ h⁻¹). In group SC the solution used consisted of diamorphine 1 mg kg⁻¹ diluted in 20 ml of 0.9% saline to give a concentration of 50 μg kg⁻¹ ml⁻¹. This was commenced at 0.4 ml h⁻¹ (20 μg kg⁻¹ h⁻¹). Diamorphine infusions were started in the recovery area. Infusions were delivered using a Graseby MS2000 pump.

After operation we used a monitoring regimen described previously [5]. Patients breathed air and had continuous monitoring of arterial oxygen saturation. We measured hourly values of ventilatory frequency, pain score, sedation score, nausea score and volume of diamorphine infused. Diamorphine was infused at a maximum rate of 20 μg kg⁻¹ h⁻¹ and boluses of diamorphine 50 μg kg⁻¹ were available if required.

Pain was assessed by a small group of experienced paediatric surgical nurses and measured using a

D. Semple, FRCA, L. A. Aldridge, FRCA, E. Doyle, FRCA, Department of Anaesthesia, Royal Hospital for Sick Children, Sciennes Road, Edinburgh EH9 1LB. Accepted for publication: September 6, 1995.
Correspondence to E.D.
Diamorphine infusions for acute pain in children

A four-point scale described previously [6]: 1 = no pain; 2 = mild pain; 3 = moderate pain; 4 = severe pain. Children were not wakened from sleep for assessments unless the nurse suspected excessive sedation. Sedation was scored using a four-point scale: 0 = eyes open spontaneously; 1 = eyes open in response to speech; 2 = eyes open when shaken; 3 = unrousable. Vomiting was scored on a three-point scale: 0 = none; 1 = vomited once in the last hour; 2 = vomited more than once in the last hour.

Infusions were discontinued when there was a consistent decline in diamorphine requirements and patients were able to take oral analgesics. Results were analysed using the Student’s t test for parametric data and the Mann–Whitney U test for non-parametric data.

The two groups were similar in characteristics (mean age 36 months in group IV and 33 months in group SC), surgical procedures (eight gastrointestinal, two pyeloplasties, three nephrectomies and two ureteric reimplantations in group IV and six gastrointestinal, two pyeloplasties, five nephrectomies and two ureteric reimplantations in group SC) and duration of surgery (median 80 min in group IV and 65 min in group SC).

The duration of infusion analgesia (median 41 h in group IV and 39 h in group SC) and total diamorphine consumption (median 680 (range 220–1120) μg kg⁻¹ h⁻¹ in group IV and 600 (260–1160) μg kg⁻¹ h⁻¹ in group SC) did not differ significantly between the groups. To assess efficacy, we compared the median total pain scores in each group during each 4-h period after operation. There were no significant differences between the groups at any point (fig. 1). Two children in group IV and three children in group SC received one supplementary bolus of diamorphine for inadequate analgesia at the maximum infusion rate.

There were no significant differences between the groups in the incidence of vomiting, excessive sedation or hypoxic episodes. Five patients in group IV and seven patients in group SC vomited. Excessive sedation was defined as a sedation score of 2 or 3; a score of 2 occurred on two occasions in one patient in group IV and on seven occasions in two patients in group SC. All episodes of excessive sedation occurred during the first postoperative day while the infusion rate was 20 μg kg⁻¹ h⁻¹. A hypoxic episode was defined as \( S_{O_2} \) less than 94%; there were 14 episodes in four patients in group IV and 18 episodes in five patients in group SC.

Two cannulae in group IV and no cannulae in group SC needed to be replaced during the diamorphine infusion.

**Comment**

We have observed that the s.c. route of administration is as effective as the i.v. route for infusion of diamorphine in children after elective surgery. Although s.c. administration has been shown to provide analgesia [3] in children, it has not been shown previously to be as effective as the i.v. route.

The fact that equivalent analgesia can be provided by this route with similar doses of diamorphine and no increase in the incidence of side effects suggests that this technique may be useful in children receiving other opioids by infusion. Use of the s.c. route for opioid infusions is likely to reduce the practical difficulties associated with the provision of this form of analgesia in small children. Intermittent injections of opioid through an indwelling s.c. cannula may be used instead of an infusion but, in common with intermittent i.m. injections, may result in periods of unrelieved pain alternating with episodes of sedation or nausea induced by high plasma concentrations of opioid after bolus dose administration. There was no blinding of observers to the type of infusion used in this study and there is the possibility of bias in the recordings. Furthermore the method of pain assessment used (observer scoring) is not as satisfactory as patient self-report and must be considered to be a relatively insensitive discriminator between analgesic regimens.
It should be noted that the subjects in this study were elective normovolaemic patients. The s.c. route would be contraindicated in patients with or at risk of developing poor peripheral perfusion when there would be a risk of accumulation of opioid at the infusion site resulting in poor analgesia and subsequent absorption of this depot to give the equivalent of a large uncontrolled bolus of opioid.

References