Significance of patient-controlled analgesia combined with continuous epidural block for patients with limb trauma

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Accepted: 8 November 1996

Summary. *Patients who were treated for fractures of the limbs were assigned to 1 of 2 groups for the management of postoperative pain. In Group 1 (postoperative patient-controlled analgesia group), 46 patients were given postoperative continuous epidural anaesthesia in combination with narcotic analgesics and this was regulated by the patient using a device. The 46 patients in Group 2 (control group) received suppositories or intramuscular injections of narcotic analgesics on their request. Patients in Group 1 needed suppositories and intramuscular injection of narcotic analgesics less often than those in Group 2, and had more satisfactory pain relief according to the visual analogue scale for pain assessment made on the first, second and third postoperative day. The time spent by nurses for pain management in Group 1 was less than that in Group 2. It appears that this patient-controlled method, combined with postoperative continuous epidural anaesthesia, is a safe, effective and efficient method for the management of postoperative pain.*

Résumé. *Des patients traités pour une fracture des extrémités étaient répartis en deux groupes pour la gestion de la douleur postopératoire. Dans le groupe I (analgésie post-opératoire contrôlée par le patient) 46 patients avaient une anesthésie péridurale continue associée à des analgésiques morphiniques dont la délivrance était réglée par le patient lui-même en utilisant un dispositif spécial.*

46 autres patients représentant le groupe II (contrôle) recevaient des suppositoires ou des injections intramusculaires d'analgésiques morphiniques sur leur demande). Les patients du groupe I ont nécessité moins d'injection intramusculaire d'analgésiques et ont eu une meilleure sédation des phénomènes douloureux d'après l'échelle visuelle utilisée pour mesurer la douleur durant les 3 premiers jours post-opératoires. Le temps passé par les infirmières pour la gestion de la douleur dans le groupe I était moins important que celui nécessaire vis-à-vis du groupe II. Il apparaît que la méthode utilisée avec contrôle par le patient de la délivrance d'analgésique en addition avec une anesthésie épidurale continue est une méthode sûre et efficace pour combattre la douleur post-opératoire.

Introduction

A recent clinical study has shown that routine intramuscular narcotic injection at the request of the patient, which is the most common management technique for postoperative pain, generally results in severe unrelieved pain in nearly half of all operated patients, and satisfactory analgesia is obtained in no more than one-third [2, 12]. In 1992, a practical guide for postoperative pain relief was published [14]. Surgical incision and subsequent noxious peri-operative events are thought to induce prolonged changes in dorsal horn neural activity and this contributes to the severity of postoperative pain [17]. The effect of prophylactic epidural anaesthesia in patients who undergo thoracic or

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Table 1. Location of limb trauma and method of anaesthesia in Group 1 and Group 2

		Group 1		Group 2	
		General anaesthesia with epidural anaesthesia	Epidural anaesthesia	General anaesthesia	Lumbar anaesthesia
Upper limb fracture	Humerus	2		2	
	Radius	8		8	
	Ulna	3		3	
Lower limb fracture	Femur	13			13
	Tibia	13	7		20

Number represents patients suffering from limb trauma

abdominal surgery has been published already [10, 15, 16]. In limb surgery, clinical evidence shows that persistent pain arising from the surgical wound is nearly as severe as in hysterectomy or gastrectomy [3]. Postoperative pain after limb surgery has been recorded recently [2, 7, 8], but no attempt was made to assess the effects of pain management in limb fractures. The aim of the present study was to determine the efficacy of combining the use of patient-controlled analgesia (PCA), with continuous epidural anaesthesia, and to see whether this would decrease the amount of time spent by nurses in the administration of postoperative analgesics.

Patients and methods

Details of the 46 patients in Group 1, and of the same number of controls in Group 2, are shown in Table 1. Surgery included intramedullary nailing for fractures of the humerus, femur and tibia, and fixation with plates and screws for fractures of the ulna and radius. The control patients (Group 2, $n = 46$) were matched to the patients who were managed by postoperative PCA (Group 1) according to the type of trauma, age, gender, postoperative management and the method of anaesthesia. General anaesthesia was induced with thiopental (3 mg/kg) and maintained with N_2O/O_2 and sevofluren. Muscle relaxation was achieved with pancronium (0.1 mg/kg). No additional analgesics were used before or during operation in either group. Patients in Group 1 suffering pain following lower limb injury were managed using 3 ml of saline containing 0.4 mg buprenorphine (2 ml) placed in a balloon reservoir (DIB International, Tokyo), connected to a patient-controlled module (PCM, Baxter Healthcare Co., Deerfield, Illinois) and this was used for the intermittent subcutaneous delivery of analgesic. By pressing the button on the surface of the PCM, patients in Group 1 were able to self-administer the analgesic (single dose = 0.5 ml saline with 0.04 mg buprenorphine) for a total of 10 doses. An automatic switch then prevented further administration for a period of 18 min. Bupivacaine (39 ml of 0.25%) combined with 0.2 mg buprenorphine was used for continuous epidural block which was given at the rate of 1.67 ml/h. In patients with upper limb trauma, epidural catheters were introduced pre-operatively via the C3–C4 or C4–C5 interspinal

space. For relief of postoperative pain in the controls (Group 2), the traditional method used was a diclofenac sodium suppository (50 mg) followed, when requested, by a fixed-dose intramuscular injection of 15 mg pentazocine combined with 25 mg hydroxyzine hydrochloride.

The visual analogue scale (VAS) was used to assess the intensity of postoperative pain during 3 periods at 0–12, 12–24 and 24–48 h after the completion of surgery [15]. The pain score was ranked on a scale of 0–10, with 0 indicating no pain and 10 the worst possible. The frequency of analgesia administered by the nurse when requested by the patients, and the mean scores in each group during the 3 periods were compared. In addition, the appearance of nausea, vomiting, pruritis, eruption, paralysis or a sensory level to pinprick were assessed, and complications and side-effects in the 2 groups were also noted.

Demographic data, VAS pain intensity score and the frequency of treatment for postoperative pain were statistically analysed by *t*-tests, Welch's tests or a chi-square test. The incidence of complications and side-effects were compared with a chi-square test. $P < 0.05$ was considered statistically significant in all tests.

Results

Pain assessment

There were no significant differences between the 2 groups with regard to age, gender, body weight, body height, intra-operative blood loss and duration of surgery (Table 2). The pain score of both groups for the period within 12 h after operation was the highest (Group 1 = 2.71, Group 2 = 7.51), and the VAS score for both groups decreased after this period. Comparison of the pain score between 12–24 h and 24–48 h after operation revealed that the mean VAS score of Group 1 decreased from 2.32 to 1.59 and that of Group 2 from 5.27 to 4.39. There were significant differences between the 2 groups with regard to the overall level of pain assessed by the VAS score for the 3 periods after surgery ($P < 0.001$) (Fig. 2).

Table 2. Demographic data of the patients in Group 1 and Group 2

Variable	Group 1	Group 2	P value
Age (yrs)	46.9 ± 24.1	51.3 ± 19.5	0.59
Weight (kg)	60.4 ± 17.4	58.5 ± 13.1	0.73
Height (cm)	160.0 ± 8.0	157.2 ± 11.5	0.80
Male/Female (n)	30/16	30/16	1.0
Duration of surgery (min)	96.1 ± 45.1	80.4 ± 48.4	0.21
Blood loss (g)	98.7 ± 51.5	95.3 ± 49.6	0.91

Mean ± SD (except for male/female ratio) There were no significant differences of demographic data between the two groups

Requests from patients for analgesia decreased during the 3 periods in the same manner as the decrease in the VAS score. The average number of times that an analgesic was administered to the patients in Group 1 was 0.23 in the period of 0–12 h after operation, 0.23 in 12–24 h and 0.16 in 24–48 h. The frequency for requiring analgesics in Group 1 during each period was significantly smaller than in Group 2 at 1.90: 0–12 h, 1.08: 12–24 h, and 0.98: 24–48 h ($P < 0.001$) (Fig. 3).

Complications and side-effects

Seven complications or side-effects were registered in Group 1: 4 patients had nausea or vomiting, 2 had urinary retention, and 1 catheter was incorrectly inserted into an epidural vein. In Group 2, 4 patients who received intramuscular injections suffered nausea or vomiting. Respiratory distress, venous thrombosis and subarachnoid block following or during puncture were not suffered by any of the patients. There was no apparent significant difference in the rate of complications or side-effects between the 2 groups.

Discussion

Clinical observations and published reports have indicated that severe postoperative pain occurs following surgery of major joints and long bones in the upper and lower limbs to the same extent as in intra-thoracic and intra-abdominal surgery [3]. Following a prospective controlled study of joint replacements and spinal operations, Colwell and Morris recommended patient-controlled analgesia for postoperative pain management both from the viewpoint of patient satisfaction and to save nursing time and cost [7]. However, the intravenous line had to remain in place for 3 days

Fig. 1. Schematic drawing of the management of postoperative pain after surgery to the lower limb. Continuous epidural block is given with a balloon infusor (DIB International, Tokyo) in which 39 ml of 0.25% bupivacaine in combination with 0.2 mg buprenorphine is administered at a speed of 1.67 ml/h. A patient-controlled module (PCM, Baxter Healthcare Co., Deerfield, Illinois) is used for intermittent subcutaneous delivery of drug solution on the patient's request. When the patient pushes a button on the surface of PCM, 0.5 ml saline containing 0.04 mg buprenorphine is subcutaneously released in a single dose. The PCM is supplied with analgesic solution from a balloon reservoir containing 3 ml saline and 0.4 mg buprenorphine (2 ml). The patient cannot perform repetitive administration because there is a protective "lock-out time" of 18 min in this system

following operation in order to deliver appropriate narcotic drugs. They found no significant difference between 2 groups with regard to the amount of narcotics used the second and third day after operation. With our routine using PCA combined with a continuous epidural block, there is no need for an intravenous line. Significant differences were noted between the 2 groups with regard to the relief of pain (VAS), and the frequency of pain care given by the nursing staff during the 3 postoperative periods.

Fig. 2. Post-operative pain intensity as assessed by visual analogue scale. The mean scores of postoperative pain intensity by visual analogue scale (VAS) for Groups 1 and 2. There were significant differences between the 2 groups with regard to the overall level of pain for the 3 periods after surgery. * $P < 0.001$

Fig. 3. Frequency of analgesic administration. The number of times that the analgesic was administered to the patients in Group 1 (an average of 0.62) was significantly smaller than that of the patients in Group 2 (an average of 3.96 times) in total. * $P < 0.001$

An important point in the control of postoperative pain is to administer an analgesic before the patient is aware of the pain [9]. Transduction and modulation of the noxious stimulation are the neural pathways for pain relief [13]. Balanced analgesia should make the analgesic act physiologically on each of these processes [15]. Epidural anaesthesia intercepts the transmission of the nociception and PCA modulates the noxious sti-

mulation. Although Bennet et al. in 1982 presented patient-controlled analgesia as a concept of postoperative pain relief [4], this method did not immediately spread as a preventive method. This was probably because the equipment for PCM consisted of an infusion pump connected electronically to a timing device, and this was too complicated and too heavy for patients to manage after surgery.

The balloon infuser which we adopted for the continuous epidural block and PCA is very simple, inexpensive and acts accurately for at least 3 days. The injection speed of the balloon infuser is 1.67 ml/h. The factor that determines the intensity of blocking of the noxious stimulation is dependent upon the amount of local anaesthetic, and this is calculated from the volume administered multiplied by the concentration. In the present study, 0.2 mg of buprenorphine in combination with 39 ml of 0.25% bupivacaine was continuously injected into the epidural space at the rate of 1.67 ml/h, and this achieved adequate analgesia when supplemented with the PCA system and without serious side-effects.

There are other advantages of the combination of PCA and continuous epidural anaesthesia. The nursing staff can concentrate on other factors of postoperative care and management, and pain is more promptly relieved. The amount of patient-controlled analgesic, therefore, can be better controlled and an overdose avoided [4].

Postoperative pain from the major joints and the long bones in the upper and lower limbs is reported to be as severe as that following intra-thoracic and intra-abdominal surgery [3]. In order to prevent this pain, it is advisable to actively control pre- and postoperative pain before and after limb surgery [1, 11, 17]. We used continuous epidural bupivacaine to block nociceptive transmission, and the subcutaneous administration of buprenorphine to modulate the nociceptive reaction, resulting in so-called balanced analgesia.

Buprenorphine may also enhance the pain-relieving effect of epidural bupivacaine. Patient-controlled analgesia which is combined with a continuous epidural block is an effective and safe method for the management of postoperative pain in limb trauma.

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