

Patient-controlled analgesia versus conventional intramuscular injection: a cost effectiveness analysis

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Abstract

In previous studies comparing patient-controlled-analgesia and intramuscular pain management have been unable to provide conclusive evidence of the benefits of either method of postoperative pain control.

Aim. The purpose of the study was to compare the efficacy and cost-effectiveness of intravenous patient-controlled-analgesia with intermittent intramuscular morphine for Chinese women in the first 24 hours following elective gynaecological surgery.

Methods. A randomized control design was used. The main outcomes were level of pain and cost for the two types of pain management. Participants indicated their level of pain at rest and when deep breathing or coughing on a 100 mm Visual Analogue Scale, on seven occasions within 24 postoperative hours. Costs for the two types of pain management were based on the costs of equipment, drugs and nursing time.

Results. A total of 125 women participated in the study. Mean pain level over the 24 hours in the patient-controlled-analgesia group was significantly lower than in the intramuscular group ($P < 0.001$). Mean pain level over the seven occasions for the patient-controlled-analgesia group was 11.83 points (95% CI 7.14-16.52) lower when at rest and 11.73 points (95% CI 5.96-17.50) lower during motion than the intramuscular group. Cost per patient was \$81.10 (Hong Kong) higher for patient-controlled-analgesia than for intramuscular pain management. Women in the patient-controlled-analgesia group had significantly greater satisfaction with pain management than those in the intramuscular group ($P < 0.001$), but reported significantly more episodes of nausea ($P < 0.05$).

Conclusions. While patient-controlled-analgesia was more costly, it was also more effective than conventional on-demand intramuscular opioid injections after laparotomy for gynaecological surgery.

What is already known about this topic

- Patients continue to experience inadequate pain relief after surgery.
- Poor control of postoperative pain has negative physiological and psychological consequences.

What this paper adds

- A systematic analysis of the comparative costs of patient-controlled analgesia and intramuscular postoperative pain management.
- Comparison of pain levels during rest and activity for each method of pain management.
- Comparison of levels of satisfaction with each method of pain management.

Introduction

Although control of postoperative pain is important for recovery, clinical surveys continue to show that many patients experienced moderate to severe degrees of pain following surgery (Royal College of Surgeons and The College of Anaesthetists 1990, Boström et al. 1997). McCaffery and Ferrell (1997) showed that over 50% of surgical patients experienced inadequate pain relief following surgery. Poorly controlled postoperative pain has negative physiological and psychological consequences. It increases the risk of atelectasis and impaired respiratory function [Agency for Health Care Policy and Research (AHCPR) 1992]. It also intensifies stress hormone responses, which can lead to tissue breakdown, increased metabolic rate, increased blood clotting, water retention and impaired immune function (AHCPR 1992).

At present, intramuscular (IM) opioid injection is the most frequently used means of pain control in the early postoperative period and is usually prescribed to be given on demand or on a pro re nata (prn) basis (Koh & Thomas 1994). It has been estimated that the IM prn approach leaves 50% of patients with unrelieved postoperative pain due to undermedication (Devine et al. 1999). Explanations for this include insufficient dosage of opioids prescribed by doctors, concern about addiction on the part of health care professionals and patients, lack of knowledge about accurate pain assessment and management on the part of clinicians, and patients' reluctance to report pain and to take analgesics (Allcock 1996, McCaffery & Ferrell 1997). Furthermore patients' perceptions of their levels of postoperative pain have been found associated with levels of anxiety (Nelson et al. 1998, Martin 1996).

Patient-controlled analgesia (PCA) has been steadily gaining acceptance in the treatment of postoperative pain. Major advantages reported include early patient ambulation, reduced thrombophlebitis and pneumonia, improved wound healing, reduced need for opioids and earlier hospital discharge (Campese 1996, Rowlingson 1999). Compared with conventional IM opioids, PCA has been found to provide better analgesia and give patients a sense of control over their pain management (Thomas et al. 1995), which could help to reduce their feelings of powerlessness and

vulnerability. While the safety record of PCA is good, side effects such as nausea, vomiting, dizziness and respiratory depression have been observed (Ballantyne et al. 1993).

Although PCA provides good pain control, some patients may be less satisfied with this method of pain management. Patients' health locus of control has an important bearing on their satisfaction with PCA (Thomas et al. 1995). Johnson et al. (1989) reported that those with external locus of control had higher levels of pain and greater dissatisfaction with PCA, while the converse was true for those with internal locus of control. Feelings of isolation and perceived lack of nursing attention may also explain why some patients are less satisfied with the use of PCA (Von Lehmann 1984).

Despite its popularity, there is a lack of randomized controlled trials identifying the clinical benefits of using PCA (Ballantyne et al. 1993). There is also a wide variation in research designs, with many studies including different surgical procedures, different kinds of drugs and different modes of delivery (intravenous, epidural, and subcutaneous). These make comparison among studies on PCA difficult. Because of small sample sizes, many of the studies lack statistical power to detect differences between PCA and IM injection of opioids (Boulanger et al. 1993, Choiniere et al. 1998). In addition, very few studies have assessed pain during activity, when it was likely to be most severe and harder to control. Kehlet (1994) estimated that assessment of pain during rest alone was done in more than 90% of the studies on postoperative pain. In order to determine analgesic efficacy, pain must also be assessed during activity such as deep breathing, coughing and/or mobilization.

With mounting health care costs, cost-effectiveness studies have become almost indispensable in shaping how resources are allocated. Although there is strong evidence from a meta-analysis to demonstrate that patient satisfaction with PCA is high, the magnitude of its analgesic efficacy compared with the conventional IM method is considerably less than expected. On a scale of 0-100, the difference in analgesic efficacy between PCA and the conventional IM method was only 5-6 units in a study by Ballantyne et al. (1993). It is, therefore, important to take a more comprehensive approach to establish the cost-effectiveness of PCA. Both its costs and benefits in contrast to those of IM pain management need to be considered. The major items in costs are equipment, analgesia and nursing time, and the benefits should be estimated in terms of the level of pain control, patient satisfaction and reduction in nursing time. At present, the economic benefits of PCA have only been looked at in terms of a reduction in nursing time (Koh & Thomas 1994, Chan et al. 1995). While Koh and Thomas (1994) claimed a saving of 48 minutes per patient per day associated with use of PCA, Chan et al. (1995) only found a saving of 1013 minutes per patient per day in cholecystectomy and laminectomy patients. Both studies suffered from problems of small sample size and multiple types of surgical procedure, and these factors made comparison difficult.

The significance of the study reported here was the use of a randomized-controlled trial with sufficient power for comparing the clinical benefits and costs for PCA with intermittent IM injection of morphine for women undergoing elective gynaecological surgery.

The study

Aims

The aim of the present study was to compare the efficacy and cost-effectiveness of intravenous PCA with intermittent IM injection of morphine for Chinese women undergoing elective

gynaecological surgery. Cost-effectiveness was measured in terms of drugs, equipment and personnel costs, demand of nursing time, analgesic efficacy, levels of pain at rest and during function, and patient satisfaction.

Design

A prospective, randomized controlled design was used to compare the effectiveness of two postoperative pain management methods for Chinese women undergoing abdominal gynaecological surgery. The study was conducted in a large regional teaching hospital in Hong Kong. All eligible patients meeting the inclusion criteria were randomly assigned either to the experimental or control group by a computer-generated random numbers table. Those in the experimental group received PCA after surgery, whereas those in the control group received the traditional IM injection. Double blinding was not adopted, as there were obvious differences in each method of pain management. However, the research assistant and ward staff were blind to the research hypotheses to reduce the influence of preconceived expectations (Portney & Watkins 2000).

Null hypotheses¹ There will be no difference in the benefits of PCA and intermittent IM pain management in:

- (a) perceived levels of pain over the first 24 hours postoperatively;
- (b) level of satisfaction over the first 24 hours postoperatively.

2 There will be no difference in the costs of using PCA and intermittent IM pain management over the first 24 hours postoperatively in terms of:

- (a) amount of analgesia;
- (b) cost (drugs, equipment, staff).

Instruments

Demographic data

Demographic data collected from all participants prior to surgery were age, date of birth, place of birth, level of education, previous surgery, marital status, number of children, occupation, indications for surgery, diagnosis and specific operation.

State anxiety

Level of anxiety experienced prior to surgery was assessed using the Chinese version of the State Scale of the State-Trait Anxiety Inventory (STAI) (Shek 1988) developed by Spielberger et al. (1970). The STAI has been used extensively in research and clinical practice to measure transient situation-related level of anxiety, and consists of 20 statements that evaluate how respondents feel 'right now, at this moment'. Participants rated each item on a 4-point Likert scale (1, not at all; 2,

somewhat; 3, moderately so and 4, very much so). The STAI had equal numbers of anxiety-present and anxiety-absent items. Anxiety-absent item scores were reversed prior to data analysis. Total possible scores ranged from 20 to 80. The scale has high reliability and validity when used with both Western (Spielberger 1983) and Chinese populations (Shek 1988, Ip 2000), and for the Chinese version in this study the alpha coefficient was 0.73.

Multidimensional health locus of control form C scale

The multidimensional health locus of control form C scale (MHLC) is an 18-item scale assessing the way people with existing health or medical condition view health related issues (Wallston et al. 1978). It comprises four subscales: internality (MHLCI) (six items), chance (MHLCC) (six items), doctors (MHLCD) (three items), and other (powerful) people (MHLCO) (three items). Participants rated each item on a 6-point scale ranging from strongly disagree (1) to strongly agree (6). Possible scores are 636 and for the MHLCD, and MHLCO 318 for the subscales (Wallston et al. 1994). Reported internal reliability of the instrument ranges from 0.72 (Frank-Stromborg & Olsen 1997) to 0.77 (Snell et al. 1997). Cronbach's alpha coefficient for the Chinese version of the MHLC subscales in this study ranged from 0.3 to 0.78.

Pain Visual Analogue Scale

Participants were asked to mark a point indicating the amount of pain using a Visual Analogue Scale (VAS), a 100 mm horizontal line with Chinese verbal anchors at either end (0, 'no pain at all'; 100, 'the worst pain imaginable'). The intensity of pain was measured according to the number of millimetres from the left end of the scale to the individual's mark (Gift 1989). This scale has had extensive use in the measurement of pain, and has been reported as a reliable and valid measure of pain intensity, with accuracy in assessing changes in pain perception over time (Gift 1989, Boulanger et al. 1993, Frank-Stromborg & Olsen 1997).

Side effect episodes

Women were asked to recall whether they had experienced any nausea, vomiting, dizziness and itching or other discomforts in the past 8 hours. This recording and observation was conducted three times within the 24 hour study period: morning, afternoon and evening.

Patient satisfaction questionnaire

A patient satisfaction questionnaire (PSQ) specific to pain management was developed for this study. It consisted of seven items relating to satisfaction with pain management, knowledge of using the particular type of pain management, overall rating of the level of pain experienced, acceptability and preference for that type of pain management in the future. Cronbach's alpha coefficient for the PSQ in this study was 0.78.

Cost-effectiveness data

The total costs for both types of pain management were determined from the amount of nursing time, equipment and drug used. Data about nursing time spent on pain-related activities were collected using nurses' self-reports. Data from patients' records were used to determine amount of analgesia, and number and types of equipment used.

Checklist for recording pain-related nursing activities. A chart was developed for ward nursing staff to record the length of time taken for a number of activities associated with pain management during the first 24 hours after surgery. The research team in collaboration with ward nursing staff identified four main types of pain-related nursing activities for this chart. Pilot testing with two nurses led to clarification in the wording of the types of activity included. This self-recording started after patients arrived on the ward and lasted for a further 24 hours. Staff salary calculations were based on the mid-point of the 7-point pay scale for registered nurse.

Amount of analgesia. After discharge from hospital, the research assistant recorded the total amount of analgesic used after surgery from each patient's medical records. This information was collected to calculate the cost of drugs used in pain management.

Equipment. The costs of all equipment associated with PCA and IM pain management were calculated. PCA costs were for the infusion pump, morphine cartridge, angiocatheter, and battery. Cost per patient was calculated by the cost of the pump divided by the estimated life-time usage. Cost of IM injections included the syringes, needles, morphine and swabs.

Sample

The criteria for inclusion in the study were that patients were Chinese, aged between 18 and 72 years and admitted to one of the two gynaecological wards for elective abdominal surgery from October 2000 to October 2001. Patients were excluded if they had a history of drug abuse, psychiatric disorder, or visual or motor disability that would interfere with the operation of the PCA machine.

To determine a medium effect size of 0.5 at power of 0.8, and a 0.05% significance level, 64 participants per group were needed (Cohen 1992). On the basis of an estimated 15% attrition rate from a previous PCA study (Boulanger et al. 1993), a total of 150 patients were approached, and 125 consented to participate. Seventeen (11%) did not complete all data collection while 8 (5%) declined to participate. Reasons for declining to participate following full explanation by the research assistant (RA) were that these women did not agree with having their pain management randomly determined. Reasons for attrition were cancellation of surgery due to a long operating list, participant health problems, non-availability of blood, incomplete data, and immediate postoperative transfer to other units such as intensive care or the surgical unit.

Data collection

Firstly, nursing and medical staff in the gynaecological wards were informed about the overall procedure for the study, including participant selection, exclusion criteria and randomization to experimental and control groups. Protocols for PCA and IM pain management were finalized following discussion with staff. The final version of the collaboratively developed chart for documenting the pain-related nursing activities was distributed to all nursing staff in the gynaecological wards.

Before surgery

One day prior to surgery, the RA identified eligible patients who met the inclusion criteria for the study. The RA provided potential participants with a full explanation of the purpose and procedures of the study and their right to refuse to participate. Following completion of a written consent, all those agreeing to participate were given a blank envelope containing the randomly generated number 1 or 2 which assigned them either to the experimental or control group.

Next, baseline data were collected: demographic data, STAI and MHLC. Participants were then given the standard preoperative teaching on pre- and postoperative care for gynaecological laparotomy surgery. The specific analgesic regimen to which they were assigned was then carefully explained, followed by an introduction to the VAS for pain assessment. The RA provided the preoperative teaching for all patients in the study to ensure consistency in process and content.

After surgery

Patients in both groups received standardized general anaesthesia. Anaesthesia was induced with propofol 1.52·0 mg kg⁻¹ and vecuronium 0.1 mg kg⁻¹, and maintained with morphine, thiopentone and nitrous oxide. On arrival in the recovery room, patients in both groups were given IV boluses of morphine to control their pain. Once their pain was controlled, those in the experimental group were connected to a PCA machine (Greasby 9300, Greasby Medical Ltd, Watford, UK) set to deliver morphine intravenously by bolus, with a lockout time of 810 minutes. For the IM group the morphine doses were 0.10·2 mg kg⁻¹, with a maximum of 10 mg three hourly. An antiemetic (metoclopramide) was prescribed on a prn basis for patients in both groups.

The first VAS pain rating was collected by the RA 30 minutes after the patient arrived back in the ward, then every 2 hours for first 4 hours, every 6 hours for next 18 hours and then at 24 hours. Two VAS readings were recorded at each time period, with the first for the level of pain while at rest and the second for the degree of pain while moving either deep breathing or coughing. Also 24 hours postoperatively, participants were requested to rate their level of satisfaction with the pain management.

After the patients were discharged from hospital, the RA recorded all the analgesic and anti-emetic drug history, as well as the episodes of side effects of the subjects.

Ethical considerations

Permission to conduct the study was obtained from the ethics committee of the Faculty of Medicine at the Chinese University of Hong Kong. Before being invited to sign the consent form, all participants were given detailed information about their rights to anonymity and confidentiality, fair treatment and protection from discomfort and harm, and were told that refusal to participate or withdrawal would not affect their treatment and care.

Pilot study

A pilot study with 12 patients was conducted over a period of 1 month prior to the actual study. This identified the necessity to modify some wording in the nursing activity chart to minimize misunderstanding. No changes were needed for the remaining study tools. The inclusion criteria were amended following the pilot study to allow all gynaecological laparotomy patients to participate in the study.

Results

Sample characteristics

A total of 125 women undergoing gynaecological surgery agreed to participate in the study. Their ages ranged from 14 to 72 years and the mean age was 44.4 years (sd 9.20). Eighty-two per cent were married and 54% had received primary education only. Forty-eight per cent were housewives and 38% were in full-time employment. Sixty-one per cent had undergone previous surgery, mainly for gynaecological surgery. The most common indication for the current surgery was uterine fibroids (48%). Table 1 compares the two groups according to type of pain management received.

Table 1 Differences in sample characteristics between patients receiving PCA and IM pain management ($n = 125$)

	PCA group ($n = 62$)		IM group ($n = 63$)		χ^2	P value
	n	%	n	%		
Marital status						
Single	12	9.60	11	8.80	0.92	>0.05
Married/widowed/separated/divorced	52	41.60	50	40.00		
Educational level						
Primary	49	39.20	45	36.00	0.72	>0.05
Secondary/tertiary	15	12.00	16	12.80		
Reason for surgery						
Serious uterine pathology	48	38.40	51	40.80	0.21	>0.05
Non-serious uterine pathology	10	8.00	3	2.4		
Ovarian tumour	6	4.80	7	5.60		
Past surgery						
Yes	41	32.80	36	28.80	0.56	>0.05
No	23	18.40	25	20.00		
Employment						
Paid employment	25	20.00	31	24.80	0.19	>0.05
Not in paid employment	39	31.20	30	24.00		

There was no significant difference between the experimental and control groups for age, anxiety state prior to surgery or the subscales of the Health Locus of Control (see Table 2).

Table 2 Differences in baseline anxiety, age and health locus of control ($n = 124$)

	PCA ($n = 62$)		IM ($n = 62$)		t-test	P value	CI	
	Mean	SD	Mean	SD			Lower	Upper
Age	45.31	8.59	43.52	9.77	1.08	0.28	-1.45	5.03
State anxiety	51.56	9.26	51.08	9.25	0.29	0.77	-2.78	3.74
Locus of control								
Chance	20.52	5.37	20.66	5.38	0.15	0.88	-2.03	1.75
Internal	20.58	4.72	21.35	4.50	0.93	0.35	-2.39	0.85
Doctor	15.92	2.08	16.95	7.86	0.99	0.32	-3.05	0.99
Other people	13.03	2.11	13.84	2.45	1.77	0.06	-1.61	-0.01

Pain

Level of pain at rest was significantly higher [$t(123) = 4.92, P < 0.001$] for the IM group than for the PCA group, and level of pain during exertion was significantly higher [$t(123) = 3.83, P < 0.001$] for the IM group than for the PCA group (see Table 3). On a scale of 0/100 measuring the intensity of pain, the mean difference in score between the PCA and IM groups at rest was 11.83 and during the exertion of deep breathing or coughing was 11.73.

Satisfaction with pain management

Overall level of satisfaction with pain management was significantly higher for the PCA group than for the IM group [$t(123) = 5.87, P < 0.001$] (see Table 3).

Table 3 Differences in means of main outcome variables ($n = 125$)

	PCA ($n = 62$)		IM ($n = 63$)		t-test	P value	CI	
	Mean	SD	Mean	SD			Lower	Upper
Pain while at rest	15.84	9.27	27.67	16.44	5.35	<0.001	-16.52	-7.14
Pain during motion	30.80	14.96	42.53	17.82	3.99	<0.001	-17.50	-5.96
Pain while deep breathing	30.81	17.12	46.77	24.31	4.25	<0.001	-23.32	-8.60
Pain while coughing	31.00	15.00	41.79	16.97	3.77	<0.001	-16.40	-5.18
Total amount of morphine	45.65	27.96	22.35	11.56	6.11	<0.001	15.82	30.78
Total satisfaction with pain management	28.84	2.70	26.03	2.54	5.99	<0.001	1.89	3.73
	<i>n</i>	%	<i>n</i>	%	χ^2			
Adverse outcomes (yes)								
Nausea	24	64.90	13	35.10	4.90	0.03	0.25	35.90
Vomiting	20	62.50	12	37.50	2.86	0.09	-4.85	31.27
Dizziness	20	60.60	13	39.40	2.17	0.14	-6.34	29.59

Analgesia use

The total amount of morphine used was significantly greater [$t(123) = 4.16, P < 0.001$] for the PCA group than for the IM group (see Table 3). While the IM protocol recommended 3 hourly prn IM Morphine, only (5/63) 8% of patients in the IM group were prescribed morphine in this way. The remaining (58) 92% had morphine prescribed at rates ranging from no prescription (3, 5%) to 4 (46, 73%) or 6 hourly (9, 14%) prn.

Side-effects

The occurrence of nausea, vomiting, dizziness, itching were measured and only nausea was found to be significantly more frequent ($2 = 4.90, P = 0.03$) for the PCA group than for the IMI group (see Table 3). No woman in either group experienced itching. The amounts of anti-emetic for the PCA group ($M = 21.27, sd = 24.33$) and for the IM group ($M = 18.71, sd = 23.01$) were not significantly different [$t(123) = 0.60, P = 0.55$]. No respiratory depression was observed in either group, and there was no significant difference in length of hospital stay [$t(118) = 0.33, P > 0.05$] between the groups.

Differences in time for pain-related nursing activities

The mean total time spent on the four pain-related nursing activities in the first 24 hours after surgery for 111 patients was 18.82 minutes ($sd = 15.10$). Data were missing for 14 patients. Nurses required significantly more time to observe patients in the PCA group than in the IM group [$t(109) = 2.19, P = 0.03$]. The amount of time nurses needed to administer analgesia was significantly greater for the IM group compared to the PCA group [$t(109) = 3.81, P = 0.001$]. However, there was no significant difference in communication, documentation or total time spent on nursing activities between the groups (see Table 4).

Table 4 Differences in pain-related nursing activity time in minutes for 24 hours

	PCA (n = 57)		IM (n = 54)		t-test	P value	CI	
	Mean	sd	Mean	sd			Lower	Upper
Communication	0.23	0.73	0.24	0.87	0.08	0.93	-0.31	0.29
Documentation	0.91	2.04	1.81	4.24	1.42	0.16	-2.17	0.37
Administration of drug	2.63	5.43	7.89	8.67	3.81	0.001	8.00	2.51
Observations	14.28	12.28	9.69	9.57	2.19	0.03	0.44	8.75
Total	18.05	14.52	19.63	15.78	0.55	0.56	-7.29	4.12

Cost-effectiveness

The cost-effectiveness analysis (Drummond et al. 1997) indicated that PCA pain management was more expensive, but at the same time more effective, than IM management. As shown in Table 4, the mean drug and equipment cost per patient for the PCA group was much higher (HK\$144.60 US\$18.45) than that for IM group (HK\$12.42/US\$1.58). On the other hand, the average human

resource requirement (nursing time) for pain-related activities over the 24-hour period was slightly less for the PCA group (HK\$52.36/US\$6.68). The total mean cost of pain management was HK\$858.34 (US\$109.48) for the IM group and HK\$939.44 (US\$119.83) for the PCA group. The HK\$79.82 (US\$10.18) difference between the total costs for the two groups indicates the cost of achieving the 11.8-point lower pain level while resting and 11.7-point lower pain level during movement for the PCA group (see Table 5).

Table 5 Cost effectiveness analysis (*n* = 125)

PCA variables (<i>n</i> = 62)	Total cost per patient (HK\$)	IM variables (<i>n</i> = 63)	Mean total cost per patient (HK\$)
Equipment (per patient)		Equipment	
PCA machine (per patient)	5.00	2.5 mL syringe	1.43
IV tubing set	5.03	15 mL morphine	8.02
Three-way stopper	2.90	Alcohol swab	0.17
Reflux valve	4.10		
Battery	5.50		
Angiocatheter no. 20	8.00		
20 mL syringe	0.36		
Tegaderm and micropore	0.80		
Ampoules of morphine	19.00		
Normal saline (140 mL)	6.75		
Large cartridge for morphine	85.00		
Metoclopramide 10 mg	2.80	Metoclopramide 10 mg	2.16
Subtotal	145.24	Subtotal	11.78
Staff			
Nursing staff 24 hours	794.20	Nursing staff 24 hours	846.56
Total cost	939.44	Total cost	858.34

Discussion

The results of this study indicate that while PCA was more costly, it had distinct clinical advantages over on-demand IM morphine in the management of pain after gynaecological laparotomy surgery. Thus, the effectiveness of PCA over the conventional on-demand IM has been demonstrated by this study.

Pain relief

Postoperative patients receiving PCA experienced significantly better pain relief during the first 24 hours than those receiving IM pain management, not only when at rest but also when deep

breathing and coughing. The magnitude of the analgesic efficacy of PCA over the IM method in this study was approximately 11.8 points on a 100 mm VAS, which is twice as much as that reported in the meta-analysis by Ballantyne et al. (1993). Our study findings differ from those in an earlier study by Choiniere et al. (1998) in which no significant differences were observed between PCA and IM groups for pain control at rest or during moving. However, patients in the IM group received regular 4-hourly injections and therefore greater amount of morphine than PCA group in that study.

In our study, the average dose of morphine received by patients in the IM group was significantly lower than that in the PCA group, which is likely to be an important factor underlying the superiority of PCA in pain control. Reasons for the lower total morphine dose in the IM group may have been patients' reluctance to have IM injections and reduced patient accessibility to the analgesic. Possible factors contributing to lower levels of analgesia for the IM group could be nurses' beliefs and practices about pain management, patients' preference for receiving analgesia and the prescribed analgesia management.

Compared with the IM patients, the PCA group of Chinese patients in the current study reported significantly higher acceptability and preference for this self-controlled type of pain management, according to the patient satisfaction scale. This finding is in contrast to the proposal by Lin and Ward (1995) that Chinese patients may be unwilling to accept responsibility for their own pain management. Passivity in health care on the part of Chinese patients has been reported previously (Shek & Mak 1987, Lin & Ward 1995, Wills & Wootton 1999). However, it may be that such passivity has diminished as patients in Hong Kong have become more used to being asked about their satisfaction with care, being involved in their treatment and becoming more educated. As suggested by Thomas (1993), patients with PCA could have experienced feelings of control, which was particularly important for helping them cope with pain on the first postoperative night, when pain was very severe. Additionally, patients may consider that their ability to control their own treatment outweighs the problems caused by drug side effects (Woodhouse et al. 1996).

Side-effects

The side-effects experienced in the study were mild. Other than a higher incidence of nausea in the PCA group, the frequency of side-effects was similar in both groups. This finding differs from that reported in a meta-analysis which showed no differences in the side-effects between PCA and IM group, while pain relief was significantly better in the PCA group (Ballantyne et al. 1993). The absence of respiratory depression (respiratory rate below 10/minute) in all patients in our study suggests that the higher dose of morphine used by patients in the PCA group did not pose any danger.

Satisfaction

Patients in the PCA group expressed a significantly higher level of satisfaction with their pain management than the IM group. Higher satisfaction with PCA is likely to be due to the superior analgesic effect (Rowlingson 1999). Additionally satisfaction would have been influenced by the ability of PCA to maintain a near constant level of analgesia and to avoid the over- or undershooting that leads to the peaks and troughs of analgesia level associated with an IM prn approach. The previously reported extreme variability in pain thresholds of individual patients requesting analgesia makes it difficult to achieve adequate pain relief through a prn IM approach

(Ballantyne et al. 1993, Forst et al. 1999). Other possible explanations for the greater satisfaction include an acceptable level of side effects and the ability to control pain management.

Cost-effectiveness

The cost for lowering pain by 11.8-points in the first 24 hours in the PCA group was HK\$79.82 (£6.52). This higher cost was attributable to the high price of the PCA equipment and greater amount of morphine used, while the difference in nursing time between the two groups was insignificant.

Choiniere et al. (1998) noted higher costs in the PCA group, although their IM group used a larger amount of morphine. Colwell and Morris (1995) reported that patients receiving IM analgesia following orthopaedic surgery had significantly greater amounts of narcotics in the first 24 hours than did the PCA group, while the opposite was found by D'Haese et al. (1998). Despite contradictory findings on the dosage of morphine usage, both studies also found that PCA pain management was significantly more expensive than IM pain management. This implies that the higher dosage of morphine used was not the major reason for the higher cost in the PCA group.

Previous studies have put emphasis on nursing time during staffing cost calculations. Two studies showed higher nursing time costs for IM pain management (Colwell & Morris 1995, Choiniere et al. 1998). In contrast, Smythe et al. (1994) found that mean nursing time per patient was higher for the PCA than for the IM group. Differences in the nursing management protocol and the way of documenting nursing activities could have contributed to the contradictory results.

In our study, the overall time spent in pain-related nursing care was unexpectedly low in both groups, suggesting that all patients did not receive sufficient pain-related nursing care. Nurses are recommended to undertake individual assessment of pain and efficacy for all patients with all types of pain management (Campese 1996, McCaffery & Ferrell 1997). Carr and Thomas (1997), in their qualitative study exploring patients' expectations and experiences of pain, found that nurses were inclined not to carry out individual pain assessment for the PCA patients as they believed that the 'high tech' machine could automatically solve pain problems. Although the protocol for pain management in our study had been clearly set out and discussed with clinical staff, failure to implement this protocol could result in suboptimal postoperative pain control. Deviation from pain relief protocols may arise from excessive workloads (Fitzgibbon et al. 1999), lack of accountability in pain management, and inadequacy in patientstaff relationships (Fagerhaugh & Strauss 1977).

Limitations

The main limitations in our study were the lack of full adherence to the protocol for IM pain management, timing of the pain assessments, duration and type of surgery, method of collecting nursing time data and the reliability for some of the locus of control scales. Although the protocol for IM pain management had been determined with the clinical staff, greater attention to current practice as well as the implementation of this protocol might have resulted in greater adherence. More specifically closer adherence by nurses to the administration of IM morphine within the parameters of the a prn prescription and regular monitoring of IM patients pain levels may have resulted in less pain for this group. While we have clearly identified the current practice for IM analgesia management for women undergoing gynaecological laparotomy, further development of the IM protocol with nursing and medical staff is likely to lead to better IM pain management.

Greater regularity in the intervals for measurement of pain would have provided a more even picture of analgesia efficiency. Absence of data on the length of time taken for surgery and type of surgery is a further limitation of this study, as these may have been confounding factors in the measurement of pain. There were limitations in using self-recording methods for determining the time spent on any nursing behaviour. However, hiring of an additional RA, which would have been necessary to ensure a more objective measurement of nursing activities, was beyond our resources. Further testing of the Chinese version of the MHLC is needed to provide a more reliable measure.

Conclusions

The level of pain experienced postoperatively by women after gynaecological laparotomy surgery was significantly lower for the PCA group compared with the IM group in this study. The cost of the approximately 11.8-point improved level of pain control for the PCA group was \$79.82. Although women in the PCA group had more nausea, the considerable gain in pain control resulted in them being significantly more satisfied with their pain management.

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