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ORIGINAL ARTICLE

Five-day pain management regimen using patient-controlled analgesia facilitates early ambulation after cardiac surgery

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Abstract
Purpose Excessive pain may interrupt early rehabilitation after cardiac surgery. The purpose of this study was to evaluate the efficacy of a longer patient-controlled analgesia (PCA) regimen for early ambulation after cardiac surgery.
Methods This study was designed to be a retrospective, single-institutional (focusing on an urban, university-affiliated hospital), pre-post intervention survey. Fifty-nine patients undergoing elective cardiac surgery were included. A long pain management regimen (subcutaneous fentanyl PCA for up to 120 h) protocol was implemented for the postoperative care for adult cardiac surgery patients. Before implementing this extended protocol, the same PCA regimen was used for up to 40 h. Perioperative and postoperative management was similar for all patients. The number of days required to walk more than 100 m without assistance was recorded. Additional usage of analgesic drugs and pain intensity on movement were documented up to POD 5.
Results Time required to walk more than 100 m without assistance was significantly shorter in the 120 h PCA group. Need for another analgesic regimen and pain score during the ambulation phase were significantly lower in the 120 h PCA than in the 40 h PCA group. Frequency of side effects was similar for both groups.
Conclusion Pain management using a PCA system can be recommended for patients during the ambulation period after cardiac surgery. Subcutaneous PCA with fentanyl is a safe and effective analgesic regimen for this purpose.

Keywords Postoperative pain · Cardiac surgery · PCA · Ambulation

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Introduction

Early ambulation is one of the key factors for a better quality of postoperative life. Poor recovery condition immediately after surgery is a predictive factor for poor quality of life [1]. Adequate pain management is essential for fast-track rehabilitation including early mobilization after abdominal surgery [2, 3]. Although pain after cardiac surgery is frequently severe [4], less attention has been paid to the management of pain during early mobilization after cardiac surgery.

Previous studies on the effect of patient-controlled analgesia (PCA) after cardiac surgery have focused mainly on early postoperative morbidity. PCA provides a better pain score [5] and reduced pulmonary complications [6] after surgery. Despite the apparently better effect of PCA on early postoperative parameters, few studies have

investigated the effect of pain management by PCA on postoperative rehabilitation after cardiac surgery.

We hypothesized that longer pain management by PCA during the early mobilization period could facilitate postoperative rehabilitation after cardiac surgery. To test this hypothesis, we compared the effect of two analgesic protocols on postoperative ambulation: one group in which subcutaneous fentanyl PCA was discontinued before ambulation, and another group in which subcutaneous fentanyl PCA was continued during ambulation.

Methods

The study was approved by the institutional ethical committee, and all patients gave their informed consent before surgery.

Study design

This study was a retrospective pre-post intervention survey of the implementation of a management protocol for postoperative vigorous pain involving the extended use of PCA. Before protocol implementation, conventional pain management using a fentanyl PCA system for up to 40 h was implemented for postoperative care of cardiac surgery patients (phase 1: from 1 May to 31 July 2006). A five-day pain management protocol including the use of a fentanyl PCA system for up to 120 h was implemented for postoperative care from 1 August 2006 (phase 2: from 1 August to 30 November 2006).

Patients

During the survey period, 108 consecutive patients underwent heart surgery involving a full median sternotomy, including off-pump coronary artery bypass grafting, valve surgery and valve surgery with coronary artery bypass grafting. Patients were excluded if they had a history of cerebrovascular disease, paralysis of the limb, prolonged (>24 h postoperatively) tracheal intubation, prolonged (>3 postoperative days) ICU stay, and withdrawing the PCA system. After patient selection, data from 59 patients (29 in phase 1 and 30 in phase 2) were reviewed based on their medical records.

Procedure

Before surgery, all of the patients were familiarized with the visual analog scale (VAS) pain score and were introduced to the PCA pump and instructed in its use. In all patients, surgical procedures and anesthetic managements were performed uniformly according to standard procedures. During the operation, the patients routinely received between 15 and 30 μg/kg of fentanyl. Postoperatively, the patients were transferred to the ICU with the tracheal tube intubated and received mechanical ventilation. If required, the patients were sedated with a continuous infusion of propofol or dexmedetomidine before extubation. The tracheal tube was removed if the patients fulfilled the extubation criteria, including hemodynamic stability, minimal bleeding (<100 ml/h), normothermia, satisfactory alertness, and a PaO_2/F_IO_2 ratio of >300 mmHg. Patients were had 24-gauge cannulas inserted subcutaneously, which were connected with a PCA system that consisted of a fentanyl solution, immediately after ICU delivery. The cannula was inserted to the anterior brachial region of the arm. The concentration of fentanyl was determined according to the patient's body weight and age (Table 1). We used a disposable PCA infusion system (Baxter, J2C1954JPCA) with a baseline flow of 0.5 ml/h, flush dosage of 0.5 ml with a lock-out time of 60 min. Phase 1 patients were connected to the PCA device which was filled with 20 ml of fentanyl solution. Phase 2 patients were connected to the same PCA device filled with 60 ml of fentanyl solution. Therefore, phase 1 patients received fentanyl for up to 40 h, whereas phase 2 patients received it for up to 120 h. The duration was shortened when the patient received bolus (each bolus shortened the duration of PCA by 1 h). Patients were allowed to use the flushing device freely, and the nurse in charge helped if required. We used a PCA device with subcutaneous (SC) injection. Although intravenous (iv) PCA is the most common procedure for postoperative patients, we did not use this because (1) most of the patients

Table 1 Deriving the concentration of fentanyl required

Age	Points
Age > 80 years	0
80 years > age > 70 years	1
70 years > age	2
Body weight	**Points**
40 kg > BW	0
60 kg > BW > 40 kg	1
BW > 60 kg	2
Points for age + body weight	**Fentanyl (μg/ml)**
4	50
3	40
2	30
1	25
0	20

Fentanyl dose was decided according to the patient's age and body weight

did not require the iv route immediately after the cardiac surgery, and (2) prolonged intravenous line insertion is associated with various complications, including bloodstream infection [7]. SC-PCA is an effective alternative to iv-PCA [8] that yields comparable analgesic effects [9] and a better quality of sleep [10]. Patients were able to receive an additional analgesic drug if this PCA was not effective. Regimens of additional analgesics were 15 mg of intravenous pentazocine or oral administration of 60 mg of loxoprofen. The physical therapist initiated early rehabilitation according to the protocol (Table 2). The procedure was suspended if an abnormal electrocardiogram was observed.

Data collection

The main outcome collected was successful rehabilitation, which was assessed based on the number of days required to walk more than 100 m without assistance. The nurse recorded the VAS number that the patient stated. All patients received uniform instructions before pain was assessed using the VAS system (0 is no pain and 100 is totally painful, as expected). Pain intensity on movement was documented three times per day up to POD 5 for the patients during both study periods. Adverse symptoms, including nausea, vomiting, respiratory depression, excessive sedation and urinary retention, were monitored by the nurse in charge and recorded. Additional usage of analgesic drugs up to POD 5 was documented.

Statistics

The data were analyzed on an intention-to-treat principle. Daily worst VAS values were analyzed using ANOVA following a Bonferroni test. Fisher's exact test was used to compare the two study groups with respect to baseline characteristics, including sex and operative procedure. An unpaired *t*-test was used to compare patient age and body weight and fentanyl dose during anesthesia. Kaplan–Meier estimates of the number of days needed for successful rehabilitation and the length of ICU stay were compared using the logrank test. Statistical analysis was performed using the software package GraphPad Prism 3.0. Differences were considered to be significant at $p < 0.05$. All of the data presented here are given as the mean ± SEM.

Table 2 Postoperative ambulation protocol

POD1	POD2	POD3	POD4
Stand up	Stand up	Stand up	Stand up
	Walk 10m	Walk 10m	Walk 10m
		Walk 100m	Walk 100m
			Walk 200m

All patients processed postoperative ambulation according to this protocol

POD postoperative day

Results

Population data including age, weight, gender ratio, operation procedure, fentanyl dose during anesthesia and length of ICU stay were comparable between the two groups (Table 3).

The fentanyl concentration of the PCA regimen was not significantly different between phases 1 and 2 (39.7 ± 1.5 μg/ml for phase 1; 40.7 ± 1.8 μg/ml for phase 2). Two patients were dropped from the analysis; one patient in phase 1 discontinued using PCA due to respiratory depression, and one patient in phase 2 felt an itching sensation and stopped using PCA halfway through. Two patients in phase 1 and 3 patients in phase 2 developed symptoms of nausea, which was successfully treated by metoclopramide.

The number of days required to walk at least 100 m was significantly shorter (logrank, $p < 0.01$) in the phase 2 group than the phase 1 group (Fig. 1). At POD 4, 87% of the patients in the phase 2 group succeeded in walking, while 48% of the patients in the phase 1 group were able to.

The daily worst VAS score on movement is shown in Fig. 2. The VAS score in the phase 2 group began to

Table 3 Characteristics of the enrolled patients

Characteristic	Group		Significance
	2 day	5 day	
N	29	30	NS
Male	19/29 (65.5%)	24/30 (80.0%)	NS
OPCAB	15/29 (51.7%)	17/30 (56.7%)	NS
Valve	12/29 (41.4%)	11/30 (36.7%)	NS
Valve + CABG	2/29 (6.8%)	2/30 (6.7%)	NS
Age (year)	63.4 ± 2.8	67.6 ± 1.9	NS
Body weight (kg)	58.3 ± 2.1	59.3 ± 1.6	NS
Fentanyl (μg/kg)	16.1 ± 1.2	15 ± 0.7	NS
ICU stay (day)	2.2 ± 0.1	2.5 ± 0.5	NS
In-hospital day	16.9 ± 0.86	17.9 ± 0.75	NS

None of the patient characteristics differed significantly between the 2 groups

NS not statistically significant

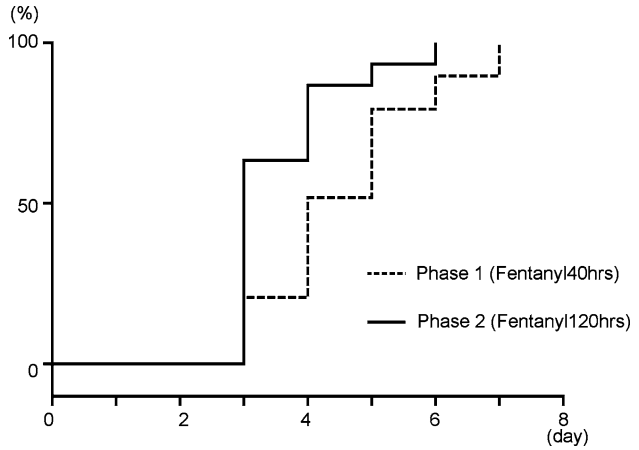

Fig. 1 Kaplan–Meier curve showing the days needed until the patients were able to walk >100 m without assistance

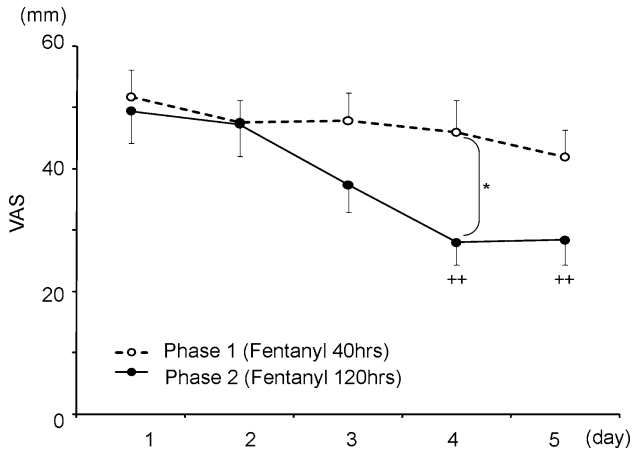

Fig. 2 Visual analog scores (VAS) for pain assessment for 5 days during the postoperative mobilization of cardiac patients. VAS ranges from 0 to 100 (mm). *$p < 0.05$ between phases 1 and 2. ++ $p < 0.01$ versus POD1

decrease at POD 3. The VAS scores in the phase 2 group at PODs 4 and 5 were significantly lower than that at POD 1 ($p < 0.01$). The VAS score in the phase 1 group, by contrast, did not decrease significantly until POD 5. Comparing between the phase 1 and phase 2 groups, the VAS score in the phase 2 group was significantly lower than that in the phase 1 group at POD 4 (46.0 ± 5.3 for phase 1; 28.1 ± 4.1 for phase 2; $p < 0.05$).

The percentage of patients who required additional analgesic drugs was significantly lower in the phase 2 group than the phase 1 group (Fig. 3; 13.3% in phase 1 and 62.1% in phase 2, $p < 0.01$). The number of attempts to receive a bolus infusion from the PCA device is indicated in Table 4.

Length of hospital stay after the operation did not differ significantly between the phase 1 and phase 2 groups (Table 3).

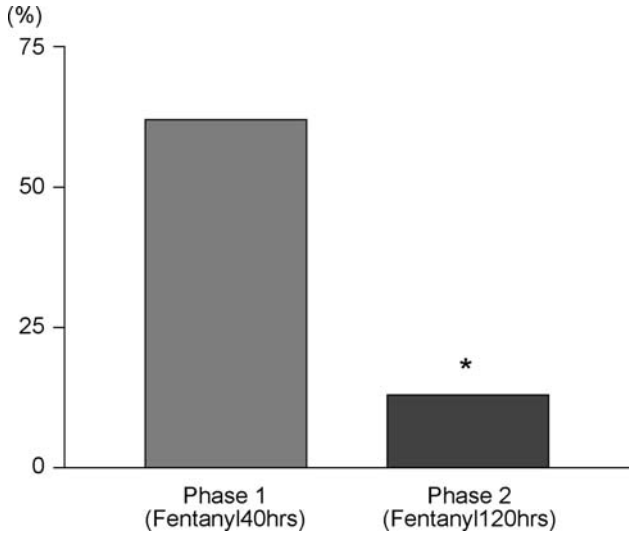

Fig. 3 Percentage of patients who required additional analgesics up to POD5. * $p < 0.01$ versus the phase 1 group

Table 4 The number of attempts to receive bolus infusion from PCA

	POD1	POD2	POD3	POD4
Phase 1	2.9 ± 0.3	1.6 ± 0.2		
Phase 2	2.7 ± 0.5	1.4 ± 0.3	0.4 ± 0.2	0.3 ± 0.1

Discussion

The present investigation demonstrates that postoperative patients who undergo cardiac surgery have a considerable amount of painful sensations during postoperative mobilization. Vigorous pain management with a PCA system during this period reduces the pain score and facilitates cardiac rehabilitation following surgery.

Pain due to median sternotomy has been thought to be weak probably due to the large amount of opioids used during the surgery [11], but recent investigations have demonstrated that patients have a high pain score immediately after surgery [4]. In addition, our results showed that, after cardiac surgery, patients feel a considerable amount of painful sensations during postoperative mobilization performed at POD 3–5. Patients in the phase 1 group, who discontinued the PCA system at 40 h, showed considerably higher VAS scores at POD 3–5 and frequently required additional analgesic drugs, including oral NSAIDs or intravenous pentazocine. Although previous investigations of intravenous PCA discontinued the PCA at POD 2–3 [12–16], we consider that employing PCA for only 2–3 days after cardiac surgery is not sufficient. Similarly, when thoracic epidural analgesia (TEA) was discontinued at POD 3, it did not shorten the length of hospital stay or rehabilitation procedure [17].

None of the phase 2 patients were reported to be drowsy, which shows that fentanyl administration according to our protocol does not affect the patients' levels of consciousness. The percentage of patients who withdrew the PCA did not differ between phases 1 and 2. Patients in the phase 2 group achieved early postoperative ambulation compared to the phase 1 group, which is associated with a lower pain scale at POD 3–5. Moreover, extended use of the PCA also reduced the percentage of patients who required another analgesia regimen. In addition to the significant effect of PCA on the physical conditions of the patients immediately after cardiac surgery [6], our results indicate that PCA, if used during rehabilitation, can improve postoperative recovery by decreasing pain intensity during mobilization and facilitating early ambulation after cardiac surgery.

In conclusion, a longer pain management regimen after cardiac surgery facilitates early ambulation after such surgery. Subcutaneous PCA with fentanyl is a safe and effective analgesic regimen for achieving this.

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