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# Impact of Patient-Controlled Analgesia on Pain Relief after Coronary Artery Bypass Graft Surgery: A Randomized Clinical Trial

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**ABSTRACT**

***Introduction:*** Pain has been pointed out as one of the concerns of cardiac surgery patients. Acute pain management has been a challenge for health professionals and several regiments have been described. We designed this study to evaluate the effectiveness of pain control with patient-controlled analgesia (PCA) versus conventional nurse-controlled analgesia (NCA) during the postoperative period in the intensive care unit (ICU) after coronary artery bypass graft (CABG) surgery. ***Methods:*** In this randomized clinical trial, 80 elective CABG candidates were selected by convenience sampling. They were randomly allocated to two groups to receive either PCA or NCA. PCA plus continuous infusion of morphine started immediately after transferring the patients to the ICU. NCA was based on intravenous injections of morphine on demand. Pain was assessed using a verbal rating scale (VRS). Sedation level and morphine consumption were also evaluated from extubation until 48 hours after surgery. Data was analyzed using $SPSS_{13}$. ***Results:*** VRS scores were higher in the NCA group compared to the PCA group [3.27 (1.17) vs. 0.75 (0.66); $p < 0.001$]. Morphine consumption was significantly higher in the PCA group compared to the NCA group [28.43 (7.15) mg vs. 8.37 (5.36) mg; $p < 0.001$]. PCA was safe and respiratory depression was not observed in any of the subjects. Mean sedation scores did not differ between the two groups. ***Conclusion:*** PCA with background infusion of morphine increases morphine consumption and improves pain relief. It appears to be superior to NCA and can be recommended for patients after CABG surgery.

## Introduction

Pain is considered as the fifth vital sign to emphasize its significance and to increase the awareness among the health care professionals. The American Pain Society and the Joint Commission standards state that "patients have the right to receive appropriate assessment and management of pain".[1]

Moderate to severe postoperative pain in cardiac surgery patients[2-4] can be caused by sternotomy, sternal retraction, intravascular cannulations, chest tubes left after surgery, and multiple invasive procedures like saphenectomy, internal mammary artery (IMA) and for some patients radial artery harvest.[5] Postoperative pain occurs at rest and is exacerbated by numerous activities such as endotracheal tube (ETT) suctioning, coughing, and physiotherapy during intensive care unit (ICU) stay that are all associated with the highest mean pain intensity scores.[2] Studies have shown removal of chest tubes to account for the highest pain scores.[3] Pain has been pointed out as one of the concerns of cardiac surgery patients.[5] Management of acute pain has been

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a challenge for health professionals and several regiments have been described.[6]

For cardiothoracic surgery patients, optimal postoperative pain management facilitates early mobilization, respiratory physiotherapy, and adequate sleep.[3] It also reduces stress, duration of mechanical ventilation, length of hospitalization, medical costs, and risk of complications such as pneumonia, atelectasis, deep vein thrombosis, and cardiac ischemia.[2,7] Moreover, improvement of pain management programs results in patient satisfaction and decreased incidence of chronic pain and insomnia.[8] While persistent pain in 10-50% of patients occurs after operations such as thoracic surgery and CABG, in about 2-10% of patients, chronic pain can be severe.[9]

Pain therapy for cardiac surgery patients in ICU includes medications that are prescribed to be administered as required (PRN). It involves intravenous (IV) administration of opioid analgesics.[3] However, there is a common belief among many nurses that cardiac surgery is not very painful.[2] Studies have shown that nurses often underestimate patients' pain and thus use inadequate analgesics.[8,10,11] Yorke et al. reported that 71% of patients had pain after cardiac surgery.[2] According to another study, patients did not ask nurses for analgesics and therefore received only 47% of their prescribed dose although they had been experiencing moderate to severe pain.[11]

Although patient-controlled analgesia (PCA) has been used for over 40 years, there is only limited data about the employment of this method in Iranian resources. People from different cultures who experience the same intensity of pain may not report or respond to it in the same ways. Hence, we designed this study to evaluate the effectiveness of pain control with PCA versus conventional nurse-controlled analgesia (NCA) during the postoperative period in ICU among CABG patients. We hope the results can be useful in improvement of programs for pain management.

## Materials and methods

This randomized clinical trial was approved by the Ethics Committee of Tabriz University of Medical Sciences, Tabriz, Iran and also registered in the Iranian Registry of Clinical Trials. Convenience sampling method was used to select 90 patients undergoing first-time CABG surgery from June to December 2011. After assessments for eligibility, five patients (two from the PCA group and four from the NCA group) were excluded because of requiring an intra-aortic balloon pump (IABP) and surgical re-exploration. Since five more individuals refused to participate, 80 patients were finally included in the study after the objectives of the study had been described, the confidentiality of information had been assured, and informed consents had been obtained.

Patients were randomly allocated by random allocation software to receive either PCA or NCA. Patients in the NCA group (n = 40) received IV injections of morphine PRN or as determined by the staff nurse until discharge from the ICU. Subjects in the PCA group (n = 40) had the pump immediately after being transferred to the ICU until discharge from the ICU. A PCA pump (disposable infusion pump, Royal Fornia Medical Equipment Co., China-U.S.) with continuous a basal rate of 3 cc/h, bolus dose of 1 mg, lockout time of 15 minutes, and a maximum of four boluses of morphine 0.01 mg/kg per hour was used.

Patients were admitted the day prior to surgery for preoperative education with an instruction booklet named "Pain relief after surgery" and bedside discussion. They were also instructed on the use of a verbal rating scale (VRS) for the measurement of postoperative pain. All patients in the PCA group were also instructed on the use of PCA pump with an instruction booklet called "Patient-controlled analgesia".

Preoperative exclusion criteria were an age over 60 years, addiction, psychiatric diseases, allergy to morphine, renal or liver dysfunction

 

(creatinine > 2 mg/dL, bilirubin > 1 mg/dL), emergency surgery, previous CABG or heart valve surgery, and poor left ventricular function (ejection fraction < 30%).

Postoperative exclusion criteria included requiring intra-aortic balloon pump, surgical re-exploration, hemodynamic instability, bleeding, and failure of the patient to properly use the PCA pump. Hemodynamic instability was defined as systolic blood pressure (SBP) less than 90 mmHg despite ongoing infusion of inotropic drugs.

Using a VRS ranging from 0 (no pain) to 10 (the worst pain ever felt), resting pain intensity was assessed every 4 hours from extubation until discharge from the ICU. The degree of sedation was also evaluated every 4 hours by a standardized sedation scoring system including 0 (none), 1 (mild: occasionally drowsy, easy to arouse), 2 (moderate: frequently drowsy but arousable), 3 (severe: somnolent, difficult to arouse), and 4 (coma: not arousable). Morphine consumption was also documented during the ICU stay. All data was collected by the nurse in charge of each patient on a separate sheet until the patient was discharged from the ICU.

Patients received their usual cardiac medication before operation and anesthesia was similar for all patients. Surgery was performed with median sternotomy by harvesting saphenous veins and internal thoracic arteries. It also included radial artery harvest for some patients. Cardiopulmonary bypass (CPB) was performed using membrane oxygenators, standard crystalloid prime, normothermia (nasopharyngeal temperature of 32-34°C) during CPB, non-pulsatile CPB flow, and myocardial protection with intermittent antegrade and retrograde cardioplegia. After CABG, patients were transferred to the ICU for delayed extubation. They returned to the ward in the morning of the third postoperative day.

Data was analyzed using independent t-test and mann witney in $SPSS_{13}$ (SPSS Inc., Chicago, IL, USA). Values are shown as mean (SD). For all statistical tests, p values less than 0.05 were considered as the minimum level of significance.

## Results

This study was conducted on 80 patients. The study protocol is shown in a flow diagram in figure 1. No statistically significant differences were demonstrated between usual care (NCA) and intervention (PCA) groups except age and ejection fraction (EF).The patients in the PCA group were younger and their EF was higher. The characteristics of patients are presented in table 1.

During the first 48 postoperative hours, the VRS scores were higher in the NCA group compared to the PCA group [3.27 (1.17) vs. 0.75 (0.66); $p < 0.001$; df = 78; t = 11.81] (Table 2).

Figure 2 shows that as expected, morphine consumption was significantly higher in the PCA group compared to the NCA group [28.43 (7.15) mg vs. 8.37 (5.36) mg; $p < 0.001$; df = 78; t = 14.19]. In spite of this, there were no significant differences between the two groups in mean sedation level ($p = 0.27$; df = 78; t = 1.09) (Table 3). Moreover, additional rectal indomethacin was used in 17 patients in the NCA group.

## Discussion

Pain management and analgesia administration are essential for stable hemodynamic, low myocardial oxygen consumption, and preventing ischemic events after cardiac surgery. Effective pain

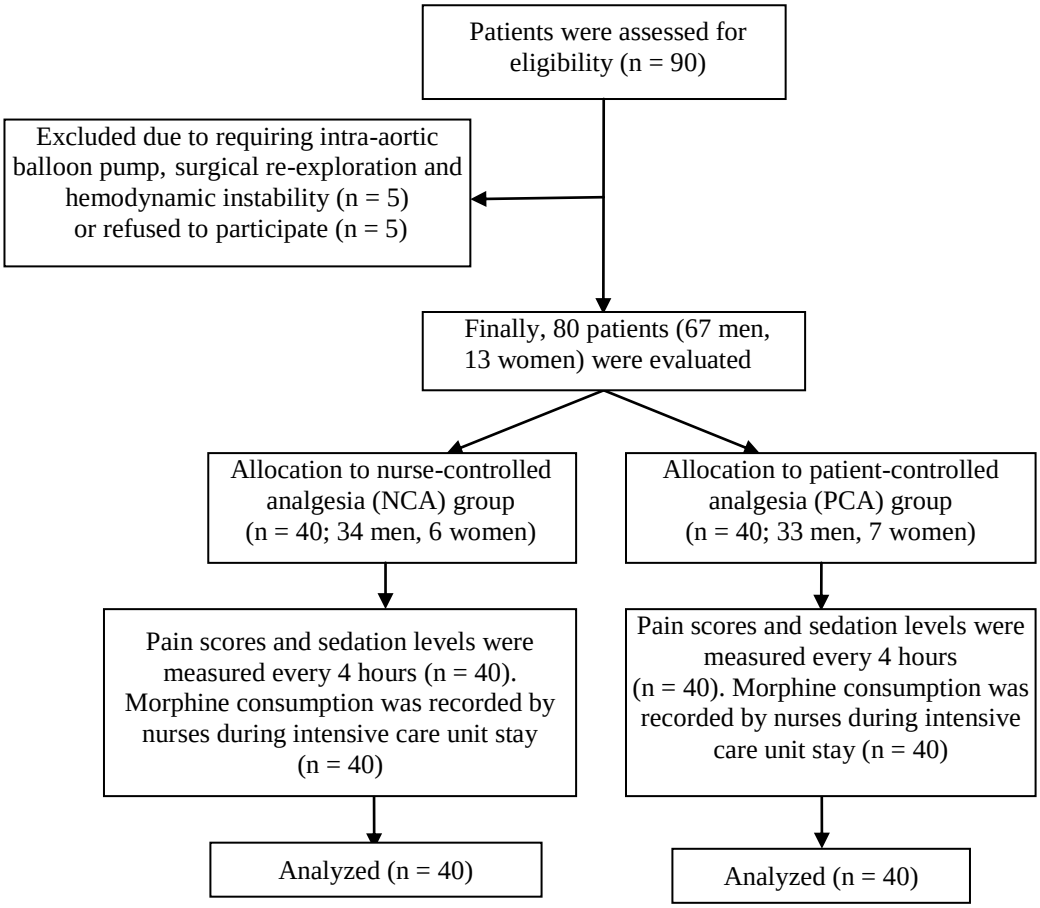


**Figure 1.** Flow diagram of trial

**Table 1.** Clinical characteristics of the participants in patient-controlled analgesia (PCA) and nurse-controlled analgesia (NCA) groups

| Characteristics | PCA group (n = 40) | NCA group (n = 40) |
|---|---|---|
| *Age (years) | 50.50 (6.50) | 53.25 (5.29) |
| **Sex (male/female) | 33 (82.50)/7 (17.50) | 34 (85)/6 (15) |
| *Weight (kg) | 80.35 (14.26) | 75.07 (11.92) |
| **Coronary anatomizes | | |
| 1 | 3 (7.50) | 2 (5) |
| 2 | 4 (10.00) | 3 (7.50) |
| 3 | 15 (37.50) | 20 (50) |
| 4 | 18 (45.00) | 13 (32.50) |
| 5 | - | 2 (5) |
| *Operation duration (minutes) | 277.00 (73.66) | 260.50 (55.29) |
| *Bypass time (minutes) | 90.17 (32.43) | 78.30 (32.64) |
| *Left ventricular ejection fraction | 50.50 (7.40) | 44.25 (9.51) |

*Values are expressed as mean (SD)
** Values are expressed as number (%)

management can also result in faster patient mobilization, reduced hospital stays, and costs.

Pain management in the postoperative period after CABG using PCA has been reported to be more effective than common NCA.[12, 13] Our study confirmed that PCA plus continuous infusion of morphine improves postoperative analgesia and

 

decreases VRS scores compared to NCA. In contrast, Tsang and Brush did not find PCA to be particularly advantageous in pain control after cardiac surgery. Their limitations were the heterogeneity of types of surgical practices (including CABG and valvular surgery) and the age range of patients (less than 75 years).[7] Studies have shown that age may affect pain and administration of analgesia after cardiac surgery.[3] In fact, patients 65 years of age or older reported less pain[1] and received less analgesia than younger patients.[3] Moreover, the type of cardiac surgery has been shown to affect the amount of pain experienced in the recovery period.[3] To be more precise, patients with an internal mammary artery (IMA) graft have been shown to have higher pain scores than those with saphenous vein grafts alone.[2,3] The difference was related to the time involved, surgical positioning, and electrocautery.[10] However, we selected patients under 60 years of age because research has suggested reduced analgesia with increasing age.[14,15] In addition, only CABG patients were included to have similar type of surgery.

**Table 2.** Pain scores on the verbal rating scale every 4 hours after extubation until discharge from the intensive care unit in patient-controlled analgesia (PCA) and nurse-controlled analgesia (NCA) groups.

| Time | PCA group (n = 40) | NCA group (n = 40) | 95% confidence interval of the difference | p | t |
|---|---|---|---|---|---|
| **Extubation time** | 1.42 (1.78) | 3.55 (2.44) | 1.17-3.07 | < 0.001 | 4.43 |
| **1st measurement** | 1.07 (1.42) | 3.77 (2.15) | 1.88-3.51 | < 0.001 | 6.61 |
| **2nd measurement** | 0.67 (0.97) | 3.70 (2.27) | 2.23-3.81 | < 0.001 | 7.72 |
| **3rd measurement** | 0.60 (0.87) | 3.77 (2.09) | 2.45-3.89 | < 0.001 | 8.85 |
| **4th measurement** | 1.02 (1.49) | 3.52 (2.09) | 1.68-3.31 | < 0.001 | 6.13 |
| **5th measurement** | 0.80 (1.20) | 3.07 (2.17) | 1.48-3.06 | < 0.001 | 5.78 |
| **6th measurement** | 0.67 (1.11) | 2.70 (1.98) | 1.30-2.74 | < 0.001 | 5.61 |
| **7th measurement** | 0.67 (1.20) | 3.07 (2.08) | 1.64-3.15 | < 0.001 | 6.13 |
| **8th measurement** | 0.32 (0.79) | 2.57 (1.61) | 1.67-2.82 | < 0.001 | 7.90 |
| **9th measurement** | 0.13 (0.44) | 2.93 (1.84) | 2.11-3.48 | < 0.001 | 8.31 |
| **Total** | 0.75 (0.66) | 3.27 (1.17) | 2.09-2.94 | < 0.001 | 11.81 |

Values are expressed as mean (SD)

**Table 3.** Sedation level every four hours after extubation until discharge from the intensive care unit in patient-controlled analgesia (PCA) and nurse-controlled analgesia (NCA) groups

| Time | PCA group (n = 40) | NCA group (n = 40) | 95% confidence interval of the difference | p | u |
|---|---|---|---|---|---|
| **Extubation time** | - | 0.75 (0.47) | -0.07-0.22 | 0.31 | 780.00 |
| **1st measurement** | 0.40 (0.49) | 0.40 (0.67) | -0.26-0.26 | 0.61 | 756.00 |
| **2nd measurement** | 0.17 (0.38) | 0.15 (0.36) | -0.19-0.14 | 0.76 | 780.00 |
| **3rd measurement** | 0.12 (0.33) | 0.17 (0.38) | -0.11-0.21 | 0.53 | 760.00 |
| **4th measurement** | 0.50 (0.22) | 0.17 (0.38) | -0.01-0.26 | 0.07 | 700.00 |
| **5th measurement** | 0.25 (0.43) | 0.15 (0.36) | -0.27-0.07 | 0.26 | 720.00 |
| **6th measurement** | 0.40 (0.49) | 0.25 (0.43) | -0.35-0.05 | 0.15 | 680.00 |
| **7th measurement** | 0.50 (0.50) | 0.30 (0.46) | -0.41-0.01 | 0.07 | 640.00 |
| **8th measurement** | 0.20 (0.40) | 0.17 (0.38) | -0.20-0.15 | 0.77 | 780.00 |
| **9th measurement** | 0.06 (0.25) | 0.09 (0.29) | -0.11-0.16 | 0.72 | 452.00 |
| **Total** | 0.22 (0.10) | 0.19 (0.12) | -0.07-0.02 | 0.27 | 690.50 |

Values are expressed as mean (SD)

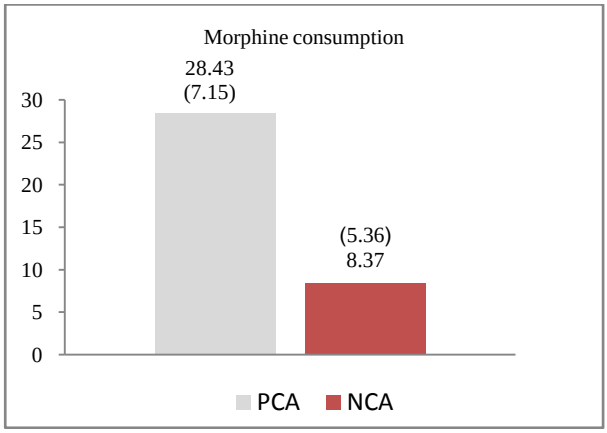


**Figure 2.** Morphine consumption (mg) in patient-controlled analgesia (PCA) and nurse-controlled analgesia (NCA) groups.

Although adding continuous infusion of morphine to PCA has been reported to enhance pain management,[16] Mota et al.[6] and Dal et al.[17] found no significant differences between PCA with or without continuous infusion of morphine. We used PCA plus continuous infusion (basal rate) of morphine because it has the advantage of providing sufficient sleep for patients without frequent interruptions by pain. However, without background infusion PCA patients must self-administer drug doses to maintain a stable analgesic blood level,[15] which may cause sleep rupture and increase the anxiety of patients. As far as we know, any intervention is most successful if it is initiated before pain sensitization occurs. Otherwise, it could be difficult to provide appropriate pain relief.

While Tsang and Brush did not find significant differences between the two groups of PCA and NCA in morphine consumption,[7] our study showed that PCA increased morphine consumption. This may be due to initiating PCA plus continuous infusion immediately after transferring the patients to the ICU until 48 hours later in our study whereas they used PCA with continuous basal rate during the first 24 hours after extubation.[7]

PCA appears to be accepted among the patients because it eliminates delays patients encounter waiting for caregivers to prepare and administer pain medication.[15] It also reduces patients' anxiety by providing immediate access to pain relieving medication.[13] Research has shown that when the opioid analgesic is prescribed PRN, nurses often administer less opioid doses than they are allowed or refuse to give analgesics despite patients' need for more analgesia.[18] The study of 225 CABG patients in three university-affiliated hospitals in Canada indicated that the majority of patients received inadequate analgesics despite experiencing considerable pain. Most patients did not voluntarily ask the nurse for analgesics and received only 47% of their PRN prescribed dose.[11] Surveys have consistently suggested that nurses tend to administer less morphine doses and prefer non-opioid analgesics due to their fear of addiction and respiratory depression (as the most serious adverse effect of morphine).[19] Similarly, in 17 patients of our NCA group, morphine treatment was supplemented with rectal indomethacin which can be interpreted as the tendency of nurses to reduce the morphine treatment.

Continuous infusions of morphine increase morphine consumption, sedation, and probably the incidence of respiratory depression.[20] One study on more than 1000 patients receiving IV PCA plus continuous infusion of morphine after major surgeries showed that respiratory depression occurred in only 13 patients.[21] In our study, none of the patients developed respiratory depression.

## Conclusion

We conclude that PCA plus continuous infusions of morphine after CABG increases morphine consumption and improves pain relief while does not considerably increase side effects.

Finally, effective pain relief needs the ability to deliver proper dose to the patient by regular monitoring of the adequacy of analgesia and any drug-related side effects. PCA with background infusion can be used effectively and safely in CABG surgery.

 

However, PCA instructions may need to be repeated during the early postoperative period because of incomplete recovery and disorientation in the ICU environment. PCA appears to be superior to NCA and can be recommended for patients after CABG.

### Limitations

Our study was not blind because the PCA pump cannot be hidden from either the patients or the nurses

## Ethical issues

None to be declared.

## Conflict of interest

The authors declare no conflict of interest in this study.

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