Ultrasound Guided PECS II Block in Minimally Invasive Coronary Artery By-pass Grafting

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Abstract

Background: Minimally invasive cardiac surgery (MICS) is less invasive than sternotomy but associated with significant postoperative pain. Regional analgesia is debatable with risk of bleeding. PECS II block is simple, less invasive technique.

Objective: To evaluate efficacy of Fentanyl IV-PCA alone or when combined with PECS II block for pain control after MICS.

Method: Sixty adult patients ASA II&III undergoing MICS were randomized to PCA group (Fentanyl IV-PCA alone) or PS group (PECS II block with Fentanyl IV-PCA). Outcome variables included postoperative fentanyl consumption (1 year outcome), time to first analgesic request, end expiratory sevoflurane, extubation time, VAS, HR, MBP, ICU stay and complications.

Results: Total fentanyl consumption 12 hours post-extubation was significantly lower in PS group than PCA group (379 ± 48.87, 480 ± 69.1 mcg, respectively; p=0.001*). Significant differences were observed intraoperative and in first six hours postoperative. No significant differences were observed in second six hours postoperative. Time to first analgesic request was significantly prolonged in PCA group (p=0.001*). End expiratory sevoflurane concentration was significantly lower in PS group (p=0.001*). More patients were extubated in OR in PS group with significant short intubation time in ICU (p=0.001*). VAS score was significantly better in PS group in first six hours post-extubation although, it began to increase four hours post-extubation but still significantly better in PS group. Significant increase in HR and MBP in PCA group at skin incision, thoracotomy, on ICU arrival and two hours later was observed. Four hours postoperative they began to increase in PS group but they still significantly lower than that of PCA group. Significant shorter ICU stay with significant lower incidence of complications was observed in PS group.

Conclusion: PECS II block provides effective analgesia in patients undergoing MICS, with less postoperative opioid consumption, better recovery, less adverse effects and shorter ICU stay.

Keywords: PECS II block; Patient's controlled analgesia; Minimally invasive cardiac surgery; Post-surgical pain; Fentanyl; Thoracotomy; Fascial plane block

Introduction

Significant pain after Chest wall surgeries e.g. sternotomy for cardiac surgery is of great concern. Good postoperative pain management in cardiac surgeries aims to achieve early recovery, ambulation, and reduce length of stay in Intensive Care Unit (ICU) [1]. Minimally invasive cardiac surgery (MICS) has significant advantages compared with traditional sternotomy. These include reduced tissue trauma, decreased blood loss, and shorter length of hospital stay [2].

Despite being less invasive than traditional sternotomy, these approaches are associated with significant nociceptive and inflammatory pain [3]. Acute postsurgical pain is typically managed with intravenous opioid analgesics. Adverse effects of opioids include respiratory depression, delirium, and gastrointestinal dysfunction,

which are particularly problematic in the aging and comorbid population undergoing cardiac surgery. Analgesic strategies that reduce opioid consumption and improve perioperative outcomes from MICS procedures are desirable [4].

Minimally invasive direct coronary artery bypass (MIDCAB) most often entails either single or multi-vessel CABG *via* a small thoracotomy, usually with the beating heart (off pump). McGinn et al. used a four to seven cm anterolateral thoracotomy in the 5th intercostal space and can harvest the left internal mammary artery under direct vision through a lateral approach. Then, six mm incisions are made in the subxyphoid area and 7th intercostal space to allow an apical positioning device and epicardial tissue stabilizer to be placed to enable exposure of all coronary artery territories [5].

Regional analgesic techniques like thoracic epidural, thoracic paravertebral block and intercostal nerve block are debatable in view of administration of anticoagulants, antiplatelet agents in the perioperative period, and the invasive and complex nature of the

procedures [6]. Other regional techniques like pectoralis nerve block and serratus anterior block are associated with sparing of analgesia in the sternum and lateral and posterior chest wall [7].

PECS II block is a novel, simple and less invasive inter-fascial regional block. Blanco et al. [8] was the first one who described ultrasound guided PECS block which used for breast surgeries. Then, PECS block has been used for multiple chest wall surgeries. First, in PECS I block local anesthetic was injected between the pectoralis muscles. Later, they modified the PECS I into the PECS II block by depositing local anesthetic into an additional and deeper muscle plane between the pectoralis minor and serratus anterior. PECS I block targets medial and lateral pectoral nerves, while PECS II block targets anterior divisions of the thoracic intercostal nerves from "T2 to T6", long thoracic nerve, and thoraco-dorsal nerve. The aim of our study was to evaluate efficacy of combination of intravenous patient's controlled analgesia and PECS II block in comparison with intravenous patient's controlled analgesia alone for control of pain after adult minimally invasive direct coronary artery bypass.

Patients and Methods

60 adult patients were enrolled in this study scheduled for elective MIDCAB surgery, aged from 30 to 60 years with American Society of Anesthesiologists' (ASA) physical status II & III, after the approval of our Institutional Ethics Committee and obtaining a written informed consent from all the participants. The trial followed the CONSORT 2010 statement guidelines for conducting a randomized controlled trial (Figure 1).

Figure 1: CONSORT flow diagram of participants through each stage of the randomized trial.
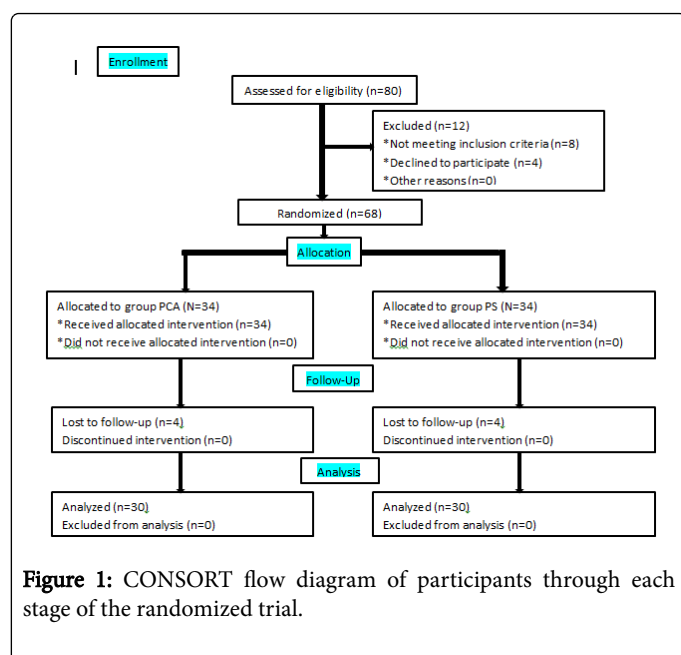
Exclusion criteria included patient refusal, coagulopathy, chronic lung disease, abnormal hepatic and renal function, uncontrolled diabetes mellitus, pregnancy, sepsis or infection at injection site, Chest wall deformity or chest wall tumor, redo surgery, allergy to any of the study drugs, opioid addiction, body mass index >35 kg/m2, need for post-operative mechanical ventilation for 6 hours or more, moderate to severe left ventricle dysfunction, coronary artery disease with left main coronary artery disease, perioperative inotropic support or intra-aortic balloon pump support for any reason, those who need on pump

CABG, uncooperative patients or those who cannot express pain intensity by visual analogue scale (VAS).

Patients were randomly assigned into two groups of 30 patients each using a computer-generated random numbers concealed in sealed opaque envelopes. A blinded nurse, who does not participate in the study or data collection, made group assignments. One anesthetist performed general anesthesia and PECS II block and another one collected data (who not informed about group assignment). All operations were done by the same surgeon. Patients assigned to one of two groups. PCA group (Fentanyl IV-PCA) and group PS (PECS II block combined with Fentanyl IV-PCA). The same general anesthesia was conducted for both groups.

A preoperative visit was conducted for history taking, clinical examination and investigations included complete blood count, coagulation profile, liver function tests, renal function tests, chest X-ray, electrocardiograph, 2D transthoracic echocardiography and coronary angiography (if present). Patients were trained how to use 100 mm visual analogue scale (VAS; 0: no pain, 100: maximal imaginable pain).

All the preoperative cardiac medications except antiplatelets and anticoagulants were continued until the morning of the day of surgery. Patients received diazepam 10 mg orally the previous night and on the morning of surgery.

On arrival to the operating theatre, monitoring (Cardiocaps/5; DatexOhmeda, Helsinki, Finland) including five leads ECG, non-invasive blood pressure, pulse oximetry and Electrodes for monitoring the Bispectral Index (BISTM, model A-2000s; Aspect Medical Systems, Norwood, MA, USA) were applied to all patients. An intravenous line and right radial arterial line for invasive blood pressure monitoring were established and secured after adequate local anesthetic infiltration. Patients were given 30 mcg fentanyl, 2 mg midazolam and local anesthetic infiltration for insertion of right internal jugular central venous catheter for monitoring of central venous pressure (CVP).

PECS II block (Pectoralis-serratus interfascial plane block) was performed before induction of anesthesia after insertion of central venous line. Patients were placed in supine position with the ipsilateral upper limb (left side) in 90° abduction position. The skin was sterilized and the ultrasound probe was covered with a sterile cap. A12 MHz high frequency linear transducer probe connected to U/S machine (Philips® cx 50 extreme edition, USA) was positioned at infraclavicular region (just medial to coracoid process); the axillary artery and vein were visualized above the first rib. Then ultrasound probe was moved caudally and laterally to reach the fourth rib. After infiltration of the skin at puncture site with 3 mL of lidocaine 1%, A 22 gauge, 10-cm, blunt insulated nerve block needle (B. Braun Medical Inc., Bethlehem, PA) was introduced in-plane approach from proximal and medial to distal and lateral upto the fascial plane between pectoralis minor and serratus anterior muscle at level of the fourth rib. After confirming a negative aspiration for blood, 30 mL of bupivacaine 0.25% was injected in increments of 5 mL (Figures 2 and 3).

Figure 2: Sonoanatomy at level of third and fourth ribs and nerve block needle advanced toward pectoralis-serratus fascial plane, pec.m=pectoralis minor muscle, Serratus m=serratus anterior muscle.
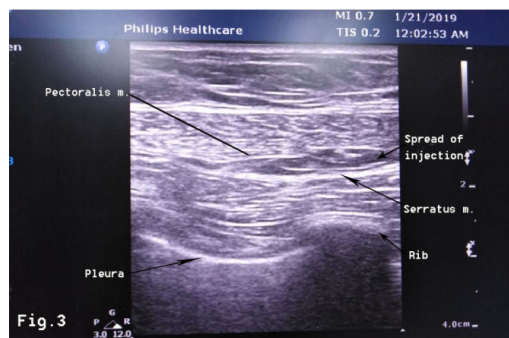
Figure 3: Ultrasound image with spread of local anesthetic injection at level of pectoralis serratus fascial plane; pec.m=pectoralis minor muscle; serratus m=serratus anterior muscle.

Success of the block and dermatomal distribution were evaluated using the pinprick test at least 20 minutes after injection of drug. Failure of block occurred if loss of sensation was not attained within 30 minutes after injection and they were excluded from the study. General anesthesia was induced in both groups by administering O$_2$ *via* a facemask, IV fentanyl 2 mcg/kg, titrating dose of propofol (1-1.5 mg/kg) till loss of consciousness, and rocuronium (0.6 mg/kg). Tracheal intubation was done using Robertshaw tube for one lung ventilation. Temperature probe for core temperature monitoring, trasesophageal (TEE) probe were applied and End-tidal CO$_2$ (ETCO$_2$) concentration was also monitored. Foley's catheter was inserted for urine output monitoring. Proper placement of external defibrillator pads was checked. Anesthesia was maintained by sevoflurane 1-2% in oxygen. Rocuronium bromide 0.3 mg/kg was given as required. Fentanyl 2 mcg/kg was given when HR or MAP increased 20% above base line in both groups. Anesthetic depth was controlled by varying sevoflurane concentration to maintain BIS between 40 and 60 and end expiratory sevoflurane concentration was recorded. Ventilator settings were adjusted to keep EtCO$_2$ between 35 and 40 mmHg.

Single vessel CABG without cardiopulmonary bypass (CPB), about 5 cm left anterolateral thoracotomy in 5th intercostal space (through this incision left internal mammary artery was accessed). Another two incisions were made; each was about 5 mm at subxyphoid and 7th intercostal space, for positioning of apical positioning device and epicardial tissue stabilizer. Distal and proximal anastomoses were done with beating heart. If there was inadequate exposure to heart or intolerance to cardiac positioning, CPB would be used with femoral cannulas and those patients would be excluded from the study.

At the end of the surgery, a trial of extubation was attempted in operating room if the patients were haemodynamically stable, normothermic, total intraoperative fentanyl not exceeded 15 mcg/kg and fulfillment of other criteria of extubation. Residual neuromuscular block was reversed with neostigmine (0.05 mg/kg) and atropine (0.01 mg/kg) and tracheal extubation was done. If not extubated in operating room, patients would be sedated with propofol and transferred for mechanical ventilation in ICU.

All patients were transferred to the ICU for close monitoring. They received paracetamol 1 gm/6 hours and ketorolac 30 mg loading dose then 15 mg/6 hours regularly. Fentanyl intravenous patient's controlled analgesia (Fentanyl IV-PCA) was used in both groups. The device was programmed to 20 mcg/ml concentration, 15 mcg/hour basal infusion rate, 30 mcg bolus dose, 15 min lockout time, 400 mcg 4 hours limit. Fentanyl IV-PCA was started on arrival to ICU and bolus dose was given if HR and MBP increased by 20% more than basal readings for the patients whom still intubated and for extubated patients bolus dose was given when VAS >30. Our primary outcome was measurement of total fentanyl consumption 12 hours after extubation. Rescue analgesia was given in the form of extra bolus dose of fentanyl IV-PCA.

Secondary outcomes were: Time to first analgesic request was measured from end of surgery to first given extra bolus dose of fentanyl. Extubation time was identified from discontinuation of anesthesia and reversal of muscle relaxant till extubation. Pain assessment using the 100 mm visual analogue scale (VAS; 0: no pain, 100: maximal imaginable pain). VAS was used during rest and assessed 20 min after extubation (VAS1) then every 2 hours till 12 hours (VAS2 to VAS7). Length of ICU stay was recorded.

Haemodynamic parameters (HR and MBP) were recorded as baseline before induction of anesthesia (HR1 and MBP1) then at the following times: skin incision (HR2 and MBP2), thoracotomy (HR3 and MBP3), opening of pericardium (HR4 and MBP4) then on arrival to ICU (HR5 and MBP5) and every 2 hours up to 12 hours post-operative (HR6 and MBP6 to HR11 and MBP11). Complications including postoperative nausea and vomiting (PONV) were recorded and metoclopramide 10 mg IV was given when needed. Other complications related to the drugs used like; hypotension (MBP of <60 mm Hg), bradypnea (RR <8), bradycardia (HR of <50 beats/min), and local anesthetic toxicity (central nervous toxicity in form of dizziness, tinnitus, numbness of tongue, metallic taste, visual disturbance and dysarthria) were recorded up to 12 hours postoperative.

Statistical analysis

Our primary outcome was total fentanyl consumption for 12 hours after extubation. Based on the results of a previous study [9], sample size calculation suggested a minimum of 26 patients in each group to detect a significant reduction in total postoperative fentanyl consumption 710 mcg at α error of 0.05, standard deviation of 890 and power of the study of 80%. Thus, in our study, 30 cases were enrolled in each group to overcome possible dropouts. Data were analyzed using Statistical Program for Social Science (SPSS) (The full detailed form is: SPSS 20, IBM, Armonk, NY, United States of America). Quantitative

data were expressed as mean ± standard deviation (SD). Qualitative data were expressed as frequency and percentage. $p<0.05$ was considered statistically significant.

The following tests were done:

-Normality of data was checked with the Kolmogorov-Smirnov test.

-Independent-samples t-test of significance was used when comparing between two means for data showing normal distribution or by Mann–Whitney U test, if not.

-Chi-square ($\chi2$) test of significance was used in order to compare proportions between two qualitative parameters.

Results

Initially, 80 patients were evaluated for the eligibility, 12 of them were excluded from the study (four patients refused to participate in the study and eight patients with moderate to severe left ventricle dysfunction). The remaining 68 patients were randomly allocated in to one of two groups (34 patients each). Eight patients were lost during follow up (in PCA group, three patients needed mechanical ventilation more than six hours and one patient needed on pump CABG; in PS group, two patients need on pump CABG and two patients needed postoperative intra-aortic balloon pump). Finally, 30 patients in each group were submitted to analysis.

Age, sex, body mass index, ASA classification, and duration of surgery were comparable between two groups (p=0.331, 1.0, 0.733, 1.0 and 0.741, respectively) (Table 1). Success of PECS II block was obtained in all patients.

Variable	PCA group	PS group	p
Age (years)	43.97 ± 10.17	46.40 ± 9.02	0.331
Sex			
Male	19	17	0.598
Female	11	13	-
BMI (kg/m2)	30.57 ± 1.41	30.70 ± 1.60	0.733
ASA classification			
II	13	12	0.793
III	17	18	-
Duration of surgery (min)	165.00 ± 11.37	166.00 ± 11.92	0.741
Values were expressed as mean ± SD or patient's number; SD: Standard deviation; BMI: Body mass index ASA: American Society of Anesthesiologists			

Table 1: Demographic data, ASA classification, and duration of surgery.

Intraoperative total fentanyl consumption was significantly lower in PS group as compared with the PCA group (307.33 ± 45.93, 638.67 ± 98.25 mcg, respectively; p=0.001). In first six hours postoperative, PS group had lower fentanyl consumption than PCA group (181 ± 25.51, 270 ± 57.89 mcg, respectively; p=0.001) while, in second six hours postoperative, no significant differences were observed between two groups (p=0.201) but, total fentanyl consumption over 12 hours after extubation was significantly lower in PS group than PCA group (379 ± 48.87, 480 ± 69.1 mcg, respectively; p=0.000). Despite high intraoperative opioid consumption in PCA group they asked for extra analgesic bolus dose earlier than PS group (45.6 ± 11.94, 273 ± 23.66 min, respectively; p=0.001) (Table 2).

Variable	PCA group	PS group	p
Intraop fentanyl (mcg)	638.67 ± 98.25	307.33 ± 45.93	0.001[*]
Fentanyl in 1st 6 hours postop (mcg)	270.00 ± 57.89	181.00 ± 25.51	0.001[*]
Fentanyl in 2nd 6 hours postop (mcg)	210.00 ± 24.91	198.00 ± 44.29	0.201
Total fentanyl post-extubation (mcg)	379 ± 48.87	480 ± 69.1	0.001[*]
Time to 1st analgesic request (min)	45.67 ± 11.94	273.00±23.66	0.001[*]
Values were expressed as mean ± SD; SD: Standard deviation; [*]Presented statistically significant difference between two groups			

Table 2: Fentanyl consumption and time to first analgesic request.

Total intraoperative end-expiratory sevoflurane concentration was significantly lower in PS group than PCA group (0.82 ± 0.16, 1.55 ± 0.49%, respectively; p=0.001) thus aided in early extubation of patients in PS group (20 patients in PS group were extubated in OR *vs.* 12 patients in PCA group) and intubated patients in ICU were extubated early in PS group. Significant short time of intubation in ICU in PS group compared with PCA group (90 ± 20.55, 212.2 ± 24.87 min, respectively; p=0.001) (Table 3).

Variable	PCA group	PS group	P
End expiratory sevoflurane concentration (%)	1.55 ± 0.49	0.82 ± 0.16	0.001*
extubation time (minutes)	212.22 ± 24.87	90.00 ± 20.55	0.001*
ICU stay (hours)	32.27 ± 7.20	26.80 ± 3.18	0.001*
Complications (%)	86.7	33.3	0.001*
Values were expressed as mean ± SD; SD: Standard deviation; % percentage ICU: intensive care unit; *Presented statistically significant difference between two groups			

Table 3: End expiratory sevoflurane concentration, extubation time, length of ICU stay and complications.

In PCA group; despite decrease intensity of pain over time postoperative, VAS scores were >30 and so, they needed repeated extra bolus dose of opioid with increased total postoperative opioid consumption. While, in PS group VAS scores were ≤ 30 up to four hours after extubation and during this period of time there was no need of extra bolus dose of opioid with significant difference between two groups (p=0.001). Four hours after extubation, VAS score began to increase in PS group but still significantly lower than that of PCA group (p=0.001). No significant differences between two groups six hours after extubation till the end of the study (Figure 4).
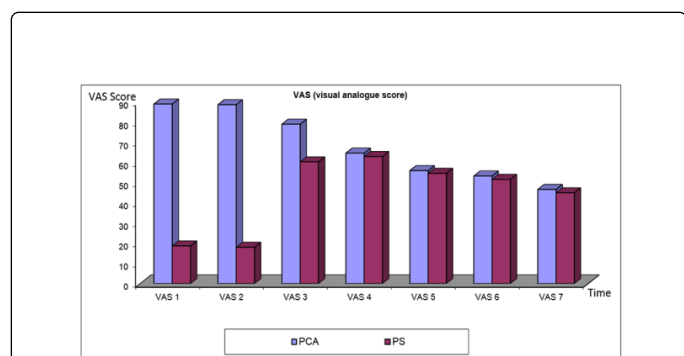

Figure 4: Visual analogue scale (VAS) changes in both groups. Data presented as mean ± SD.

Intraoperative there was significantly increased HR in PCA group compared with PS group at skin incision and thoracotomy with significant differences between two groups (p=0.001). While, no significant differences between two groups regarding HR during opening the pericardium. Postoperative, HR was significantly increased in PCA group compared with PS group on arrival to ICU and two hours later (p=0.001). Heart rate began to increase in PS group four hours postoperative but still significantly lower than that of

PCA group (p=0.045). While no significant differences between two groups six hours postoperative till the end of the study (Figure 5).
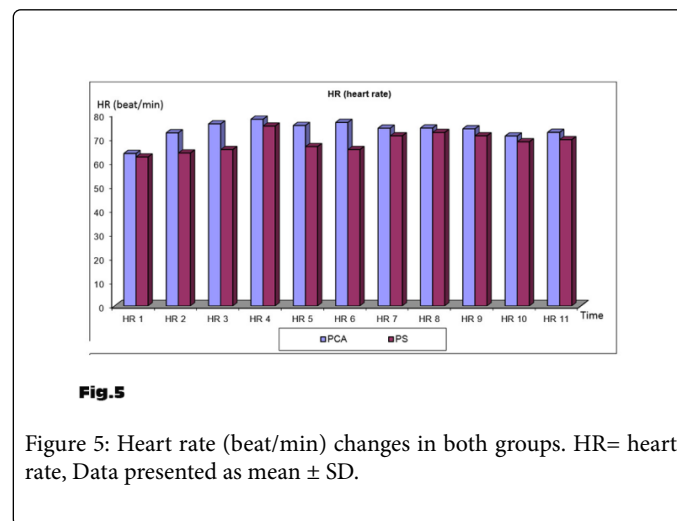

Figure 5: Heart rate (beat/min) changes in both groups. HR= heart rate, Data presented as mean ± SD.

Intraoperative there was significantly increased MBP in PCA group compared with PS group at skin incision and thoracotomy with significant differences between two groups (p=0.001). While, no significant differences between two groups regarding MBP during opening the pericardium. Postoperative, MBP was significantly increased in PCA group compared with PS group on arrival to ICU and two hours later (p=0.001). Mean blood pressure began to increase in PS group four hours postoperative but still significantly lower than that of PCA group (p=0.006). While no significant differences between two groups six hours postoperative till the end of the study (Figure 6).
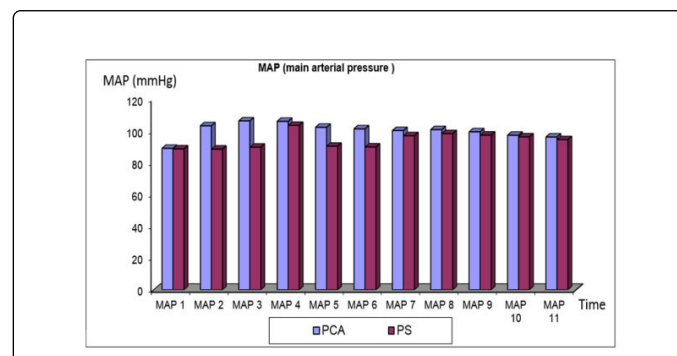

Figure 6: Mean arterial blood pressure (mmHg) changes in both groups. MAP=mean arterial pressure, Data presented as mean ± SD.

Shorter ICU stay was significantly observed in PS group as compared with PCA group (26.80 ± 3.18, 32.27 ± 7.20 hours; p=0.001) (Table 3).

Incidence of complications was significantly higher in PCA group compared with PS group (86.7% *vs.* 33.3% respectively; p=0.001). Postoperative nausea and vomiting was observed in 12 and 5 patients in PCA and PS group respectively. Hypotension was observed in 4 and 1 patients in PCA and PS group respectively. Pruritus was observed in 10 and 4 patients in PCA and PS group respectively (Table 3).

Discussion

Our trial demonstrated that combination of PECS II block (pectoralis-serratus fascial plane block) with fentanyl intravenous patient's controlled analgesia (Fentanyl IV-PCA) provided better control of pain in adult submitted to minimally invasive cardiac surgery than use of Fentanyl IV-PCA alone. Thus, reducing not only postoperative opioid consumption but also intraoperative consumption of both opioid and inhalational anesthetic hence, better recovery with early extubation, less adverse effect and shorter ICU stay. Number of trials showed that PECS II block provided postoperative analgesia for patients undergoing modified radical mastectomy and reduce total opioid consumption without causing any adverse effect [10-12].

Only few case reports and clinical trials described successful use of PECS II block for analgesia in a non–breast-related chest wall surgery. Our results showed that PECS II block reduced use of intraoperative inhalational anesthetic and opioid consumption not only intraoperative but also postoperative providing efficient postoperative analgesia for about six hours postoperative, Farkas et al. described in their case report that PECS II block successfully provided intraoperative anesthesia and postoperative analgesia for a patient undergoing transthoracic arteriovenous graft repair. The PECS II block also minimize the use of general anesthesia and opioid dosing so, minimizing the potential adverse sequelae of general anesthesia and other more invasive regional techniques [13].

Yalamuri et al. reported a case complained of severe pain and shallow breathing on postoperative day 1 after minimally invasive mitral valve replacement and failed to respond to intravenous opioids. After performance of PECS I and II block, pain score was markedly decreased with improvement of respiratory mechanics. The same occurred in postoperative day 3 and repeated block was performed. So, PECS I and II block is an effective method for opioid sparing post-thoracotomy pain management [14].

In current study, post-operative pain control lasted for about six hours. Duration of analgesia provided by PECS II block depends on type and concentration of local anesthetic. Similar results obtained by Blanco et al. [8] and Kulhari et al. [10] as they showed that the effective analgesia time was eight hours and 294.5 minutes respectively. The former report used dose of 0.25% levobupivacaine and the latter report used ropivacaine at high concentration (0.5%). On contrary, Shorter duration of analgesia (3 hours) provided by Shakuo et al. when using PECS II block for postoperative analgesia in patients undergoing transapical transcatheter aortic valve implantation. They used ropivacaine at concentration of 0.25%. They extended duration of analgesia by catheter insertion for continuous infusion. They recommended revision of catheter tip especially when the block couldn't provide adequate analgesia [15].

Our results demonstrated that efficient intraoperative and postoperative analgesia with less adverse effects obtained in the group received PECS II block which aided in early extubation and reduced length of ICU stay. On the other hand, Kaushal et al. when comparing the efficacy of ultrasound guided PECS II block with other regional techniques for management of postoperative thoracotomy pain after pediatric cardiac surgery, they reported that PECS II block reduced requirement of intraoperative opioid and postoperative rescue analgesia providing postoperative analgesia for 10 hours with early extubation but adverse effects were comparable with other groups received other regional techniques [16]. Moreover, Schuitemaker et al.

concluded that the PECS II block provided highly effective regional analgesia for clavicle operations with minimal adverse effects [17].

Limitations of the study were: first; single shot PECS II block was time limited. Insertion of catheter for continuous infusion and use of different drugs with different concentrations need to be evaluated to extend the duration of analgesia. Second; PECS II block combined with intravenous opioid analgesia was compared with intravenous opioid analgesia alone. So, PECS II block need to be compared with other regional techniques or combination of them to avoid use of postoperative opioid analgesia.

Conclusion

PECS II block provides effective analgesia in patients undergoing MICS, with less postoperative opioid consumption, better recovery, less adverse effects and shorter ICU stay.

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