

Application of preemptive parasternal intercostal nerve block in patients undergoing off pump coronary artery bypass grafting:A Double-Blind,Randomised, Controlled Trial

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Research article

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Abstract

Background: Parasternal intercostal nerve block as superficial block has been increasingly used for postoperative analgesia via performed before sternal suture placement, and has shown that this technique can provide effective postoperative analgesia and facilitate rapid-recovery. However, the impact of preemptive parasternal intercostal nerve block has not been researched for cardiac surgery patients.

Methods: Sixty-four patients underwent OPCABG were randomly divided into parasternal intercostal nerve block with ropivacaine (n = 32) group and parasternal intercostal nerve block with saline (n = 32) group. Before anaesthesia induction, 20ml of 0.35% Ropivacaine along with 1 mg dexamethasone or saline on each side, total dosage 40 ml, via parasternal intercostal injection. 5ml of 0.35% ropivacaine along with 0.5 mg dexamethasone or saline on each leg, total dosage 10 ml, via peripheral saphenous nerve block.

Results: The consumptions of intraoperative sufentanil and vasopressor were significantly lower in ropivacaine group ($P < 0.05$). Analgesia was adequate in the ropivacaine group up to 20 h. VAS score in the ropivacaine group significantly was lower compared with the saline group up to 12 h postoperatively ($P < 0.05$). The time of first rescue analgesic, anaesthesia recovery and extubation were significantly less in patients of the ropivacaine group ($P < 0.05$). The majority of the ropivacaine group patients did not need rescue dezocine, while the most of the saline group needed dezocine ($P < 0.05$). The hemodynamic variables were stable in all patients. Few cases reported trivial adverse effects.

Conclusions: Preemptive parasternal intercostal nerve block provide adequate analgesia for the first 20 h after surgery and reduce intraoperative sufentanil, intraoperative norepinephrine and postoperative dezocine consumption as well as the time of extubation. Trial registration: The study was registered at chictr.org.cn (identifier: ChiCTR1800017210) Registered 18 July 2018).

1. Background

Off pump coronary artery bypass grafting (OPCABG) is one of the major surgical treatments for coronary heart disease. Maintaining the stability of intraoperative hemodynamics and myocardial protection has been one of the hot topics in the field of cardiac anaesthesia. Adverse perioperative pain stimulates the neuroendocrine system and causes stress, which has adverse effects on the cardiovascular system, respiratory system, and digestive system.(1, 2) Effective postoperative pain control may be benefit for early extubation, as well as cost reduction and rapid recovery.(3-5) In addition, appropriate analgesia can reduce morbidity related pain.

Acute thoracotomy pain is multifactorial in nature. It involves nociceptive and neuropathic mechanisms originating from somatic and visceral afferents. The main source of pain is intercostal nerves. Therefore, a multimodal analgesic approach is recommended.

A large number of studies on epidural anesthesia and thoracic paravertebral nerve block for postoperative analgesia after cardiac surgery have shown that both techniques can provide effective postoperative analgesia and improve postoperative mortality.(4, 6-10) but due to the corresponding complications caused by the deep depth of the needle, especially in the treatment of antiplatelet or anticoagulant, which

is usually administered to elderly patients with OPCABG, these techniques are still controversial.(11, 12) In order to avoid above of complications, parasternal intercostal nerve block has been suggested as it is a “superficial block”, compared to epidural anesthesia and thoracic paravertebral nerve block. Recently, there have been a large number of studies on the efficacy of parasternal nerve block for postoperative pain in cardiac surgery,(13-17) but the effectiveness of preemptive parasternal nerve block for cardiac surgery has not been reported. It was therefore considered in this study that, parasternal intercostal nerve block could be used not only postoperatively, but also intraoperatively.

2.methods

The randomised controlled trial was approved by the local research ethics committee (The Second XIANGYA Hospital of Central South University, Chairperson Jing Ping Zhao, ref: 2018-024) on 29 March 2018, and registered with ChiCTR (ref: ChiCTR1800017210). The study was performed at the Second XIANGYA Hospital, during the period from 20 July 2018 to 30 September 2018. All patients gave written informed consent before participating in the study. Coronary angiography revealed coronary artery multivessel diseases, and 64 patients with OPCABG surgery were selected, regardless of gender. The inclusion criteria were as follows: Age 45 to 75 years old, weight of 40-90 kg, ASA \leq II or III, NYHA I ~ II, no valvular disease, without Intra-Aortic-Balloon-Pump, and no neuropsychiatric disorder.

Exclusion criteria were as follows: infection of the puncture site; left ventricular ejection fraction <50%; chronic liver or kidney disease; allergy to amide-type anesthetics; Low cardiac output syndrome with inotrope and/or intra-aortic balloon pump support. Other reasons for withdrawn were changing to cardiopulmonary bypass during operation, postoperative complications requiring re-operation, requiring intra-aortic balloon pump support intraoperative or postoperative, postoperative tracheal intubation again, and sedation for more than 48 h.

After obtaining written informed consent from the 64 participating adults, using the sealed envelope method, 64 participants undergoing OPCABG were randomized into group R or group S and administered with either ropivacaine or saline. Medication administration and data collection were performed in a double-blinded manner, such as one anaesthesiologist prepared the ropivacaine or saline and administered the block, other anaesthesiologist administered anaesthesia and collected the data, the intensive care unit staff gave postoperative care.

The parasternal intercostal block primarily anesthetized the intercostal nerves close to the sternal border and the anterior cutaneous branch of the intercostal nerve. For parasternal intercostal nerve block Patients, 0.35% ropivacaine and 1 mg dexamethasone or 0.9% saline were administered with 20 mL aliquots through injection into the space between the Intrathoracic fascia and T3–T4 anterior intercostal muscle on each side 2-2.5 cm lateral to the sternal edge by ultrasound (Fig.1). The block was administered by an anesthesiologist in a standardized fashion guided by ultrasound before anaesthesia induction. Take care to ensure that no blood was aspirated to avoid intravascular injection resulting in local anesthetic intoxication. In addition, patients were treated with peripheral saphenous nerve block

with 0.35% ropivacaine and 0.5 mg dexamethasone or 0.9% saline administered in 5 mL aliquots on each leg, as well as under the guidance of ultrasound (Fig.2).

Standardized anesthesia program for all patients enrolled in the study. Intramuscular 10 mg of morphine and 0.3 mg of scopolamine were administered 2 hours before surgery. Anaesthesia was induced with midazolam (0.05-0.1 mg kg⁻¹), sufentanil (0.3-0.7 ug kg⁻¹), vecuronium (0.1-0.2 mg kg⁻¹), and etomidate (0.03 mg kg⁻¹) and maintained with a TCI infusion of propofol (1.0-3.0 ug ml⁻¹) and remifentanyl (1.0-4.0 ng ml⁻¹) and an infusion of cisatracurium (0.1 mg kg⁻¹ h⁻¹). ECG, Spo₂, HR, CVP, BIS and arterial blood pressure were monitored during the operation.

All patients were transferred to the intensive care unit of cardiac surgery after surgery and performed postoperative management. The postoperative analgesia protocol involves the use of intramuscular 5 mg of dezocine as required, in addition to 2 tablets of oral somedon were also administered.

During the operation, the causes of hemodynamic changes were comprehensively considered, whereas BIS and CVP monitoring were combined to provide the corresponding treatment, including adjustment of anaesthesia depth, fluid infusion, intravenous analgesics (mainly sufentanil), intravenous vasoactive drugs and other treatments.

The primary outcome measures for this study included intraoperative hemodynamics, dosages of sufentanil and intraoperative norepinephrine, sternal wound pain for 48 hours after surgery, and postoperative analgesia requirements. Visual analog scale (VAS) was used to assess postoperative pain.

Other postoperative data collected were times of anesthetic recovery, postoperative ventilation, ICU stay and hospital stay. Postoperative nausea, vomiting, and other complications occurred among the patients.

3.statistical Analysis

Continuous variables were presented as means with standard deviations, and groups were compared by using a 2-sided Student t test with equal variance. The intra-group comparison was performed by repeated measures analysis of variance. χ^2 test (Fisher's exact test) was used to examine the relationship between qualitative variables. The tests were performed using Statistical Analysis System software. The power of the study was 85%, so, in this work the sample size was sufficient in each group. Significance was set to a *P*-value < 0.05.

4. Results

Sixty-four patients were randomized (28 ropivacaine and 27 saline). Four patients from the ropivacaine group and five patients from the saline group were withdrawn from the study (Fig. 3). For the ropivacaine group, patients were withdrawn for the following reasons: 2 patients were under postoperative sedation for more than 48 h and 2 patients required intra-aortic balloon pump support. Of the saline patients who were withdrawn, 2 required intra-aortic balloon pump support, 2 were under postoperative sedation for

more than 48 h and 1 required additional tracheal intubation due to low oxygen in the blood. Patients' demographics and baseline clinical characteristics were similar between the two groups (Table 1). Patients who received ropivacaine had significantly less dose of sufentanil at the time of skin incision, median sternotomy and total consumption (Table 2), especially at the time of median sternotomy and total consumption of sufentanil were approximately 50% lower in the ropivacaine group ($P < 0.001$).

Hemodynamic data showed that patients were hemodynamic stable between the two groups. Hemodynamics (heart rate, Mean artery pressure) were no statistically significant differences between the ropivacaine and saline groups (Fig. 4). However, at the time of the dissection of IMA, 5min after reperfusion, closure of sterno and the end of surgery, patients who received ropivacaine had significantly less dose of norepinephrine ($P < 0.05$) (Table 2).

The pain scores (VAS) over a 48-h period are depicted in Fig. 5. Patients experienced less pain over the first 12 h after surgery in the ropivacaine group. The VAS scores of the ropivacaine group were lower than the saline group at 6 h, 8 h as well as 12 h after the operation ($P < 0.05$). The difference of VAS scores at 18 h, 24 h, and 48 h after the operation was not statistically significant. Time of first rescue analgesic after operation in the ropivacaine group was significantly later than that in the saline group ($P < 0.05$) (Table 3). The most of ropivacaine group patients did not need rescue dezocine doses, while the majority of saline group needed dezocine ($P < 0.05$) (Table 3). The time to recover from anaesthesia and extubation were significantly lower in the ropivacaine group ($P < 0.05$). Nevertheless, no effect was shown on the length of stay in ICU and hospital after surgery for the ropivacaine group (Table 3).

Postoperative nausea and vomiting occurred in 3 patients in the ropivacaine group, and 4 patients in the saline group and there were no complications related to nerve block in either group.

5 Discussion

Hemodynamic stability is a significant concern in the intraoperative management of OPCABG. In the past, large doses of opioids were used in thoracotomy to inhibit the stress response caused by strong stimuli such as skin incision, saw sternum and chest closure. However, opioids are associated with side effect such as inhibiting the cardiovascular system, making it unsuitable for maintaining the stability of intraoperative hemodynamics. Our study demonstrated that ropivacaine with application of the parasternal intercostal nerve block before surgical incision, intraoperative opioid was decreased. There was no difference in hemodynamic parameters between the ropivacaine group and the saline group but norepinephrine consumption was decreased in the ropivacaine group that probably indicates that parasternal nerve block can maintain hemodynamic stability to a certain extent.

In recent years, general anaesthesia combined with regional anaesthesia has become a hot topic. The current regional anaesthesia for thoracotomy encompasses both thoracic epidural anaesthesia and thoracic paravertebral nerve block. Scott et al. studied the potential benefits of thoracic epidural anaesthesia and analgesia in patients undergoing coronary artery bypass grafting.(4) Dango et al. combined paravertebral and thoracic epidural analgesia for post-thoracotomy analgesia,(18) they found that epidural anaesthesia and thoracic paravertebral nerve block significantly provided effective

postoperative analgesia, and conferred myocardial protection. A recent systematic review reported thoracic paravertebral nerve block may be as effective as thoracic epidural analgesia for post-thoracotomy pain relief.(19) but due to the complications such as perioperative hypotension, infection, hematoma, nerve injury, and total spinal anaesthesia, both of them were remain debate.

In view of its easier application and lower complication rate, Saad et al showed that preemptive thoracic paravertebral block and serratus anterior plane block provide comparable levels of adequate analgesia for the first 24 h after thoracotomy. The two procedures reduce intraoperative fentanyl and postoperative morphine consumption.(20) In our study, we used the superficial technique to compared the US-guided with parasternal intercostal nerve block with ropivacaine to saline. The local anaesthetic can be injected superficial to the anterior internal intercostal muscle. The results of this study were in favor of parasternal intercostal nerve block regarding the analgesic efficacy. On the other hand, parasternal intercostal nerve block appeared to be more safe in view of the lower rate of adverse events especially hypotension and bradycardia.

Nerve block of local anesthetics for postoperative analgesia in different surgical settings has been studied and has been shown to be effective in reducing postoperative pain. Although the same method directly used in cardiac surgery has been studied, the results are still controversial(15, 21, 22). This study demonstrated that the parasternal intercostal nerve block provided adequate analgesia for the first 12 h after surgery. Pain intensity was significantly lower with the ropivacaine group compared with the saline group after 12 h. Time of first rescue analgesic in the ropivacaine group was at an average of 20 h after surgery, while an average of 13 h in the saline group. The current study also showed administration of one or more doses of dezocine during the 48-postoperative h for all except 17 patients in the ropivacaine group. The saline group required higher doses of dezocine for all except 9 patients. Therefore, parasternal intercostal nerve block reduced dezocine consumption but was not adequate as the only postoperative analgesic. Barr et al studied postoperative bilateral parasternal nerve block for cardiac surgery patients, they found that parasternal nerve block provided good postoperative analgesia. The efficacy of ropivacaine was maintained until 24 h after extubation.(14) In the current study, the effect of local anesthetic in the ropivacaine group lasted up to 20 h after surgery. This may be related to the inclusion of dexamethasone to enhance the compatibility of local anaesthetics. Studies have shown that local anaesthetics with dexamethasone can effectively extend the action time of local anaesthetics.(23, 24) Additionally, studies of continuous local anesthetic injections in patients with sternal trauma also have produced different outcomes for reducing postoperative PCA analgesics,(14, 25) The data from our study also confirmed that these studies provide good postoperative analgesia for the parasternal intercostal block. Most of researches on parasternal nerve block for postoperative analgesia were performed after cardiac surgery. In this study, we adopted the concept of preemptive analgesia through the application of regional blocks before surgical incision. This approach focuses on postoperative analgesia in addition to prevention of central sensitization and chronic neuropathic pain.(26)

Poorly managed pain following cardiac surgery can lead to increase the risk of complications such as lung collapse and chest infections due to altered mechanical functions of the lungs and ventilation-

perfusion mismatch. effective relief of sternal pain is important for both patients and doctors. Increasing evidence suggests that severe pain in the sternum after surgery seriously affects the time of removal of the tracheal tube, hemodynamic stability, and subsequent postoperative recovery.(2, 27, 28) Studies by Barr et al. and McDonald et al. showed that parasternal intercostal block significantly improved oxygen. (14, 15) Regrettably, our research has not yet monitored this indicator.

In this study, the time of recovery from anaesthesia and intubation was lower in the ropivacaine group compared with the saline group, which may be related to the reduction of intraoperative sufentanil dose, but there was no difference in ICU monitoring time, and postoperative hospital stay. This was probably due to the intensive care unit has strict criteria for transfer out of the ICU. Apart from parasternal nerve block, recovery of myocardial function, use of postoperative vasoactive drugs and hemodynamic stability are also important factors that influence the time of ICU stay.

6. Limitations

The outcomes of this study are, however, limited to the short-term effect of parasternal intercostal nerve block. Hence, its long-term effects need to be further studied. In addition, there was no observation in intraoperative and postoperative serological indicators, postoperative hemodynamics indicators, postoperative vasoactive drug use, and changes in myocardial enzymes. These were a limitation of this study that needs to be explored in further studies.

7.conclusion

In conclusion, this study has demonstrated an effective and practical treatment for off pump coronary artery bypass grafting. A parasternal intercostal block results in reduced consumption of opioid, higher hemodynamic stability, less postoperative pain and adjuvant analgesia in the general cardiac surgery population.

8.abbreviations

OPCABG: Off pump coronary artery bypass grafting

ASA: American Society of Anesthesiologists

NYHA: New York Heart Association

BMI: Body Mass Index

ECG: Electrocardiogram

HR: Heart Rate

CVP: Central Venous Pressure

BIS: Bispectral Index

VAS: Visual Analog Scale

ICU: Intensive Care Unit

IMA: Internal Mammary Artery

US: Ultrasound

PCA: Patient Controlled Analgesia

T3-T4: Third to Fourth intercostal space

9.declarations

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Availability of data and materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions: This research was accomplished by three co-authors; the contribution of each author are as follows: MMZ was involved in designing the study, accomplishing the work of postoperative follow-up, collecting the total of the data, and drafting the manuscript; JMX instructed the design of the research protocol and performed the nerve block technique; WR participated in designing the intraoperative part of the research protocol ,performed the general anesthesia processes and gave some instructions in designing and writing the manuscript. All authors have read and approved the final manuscript.

Ethics approval and consent to participate: The research protocol was approved by the Medical Ethics Committee of the Second XiangYa Hospital of Central South University, Changsha, China(Number: 2018-024), and all the patients signed the written informed consent voluntarily.

Consent for publication: Not applicable.

Competing Interests: The authors declare that they have no competing interests.

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Tables

Due to technical limitations the tables have been attached as supplemental files

Figures

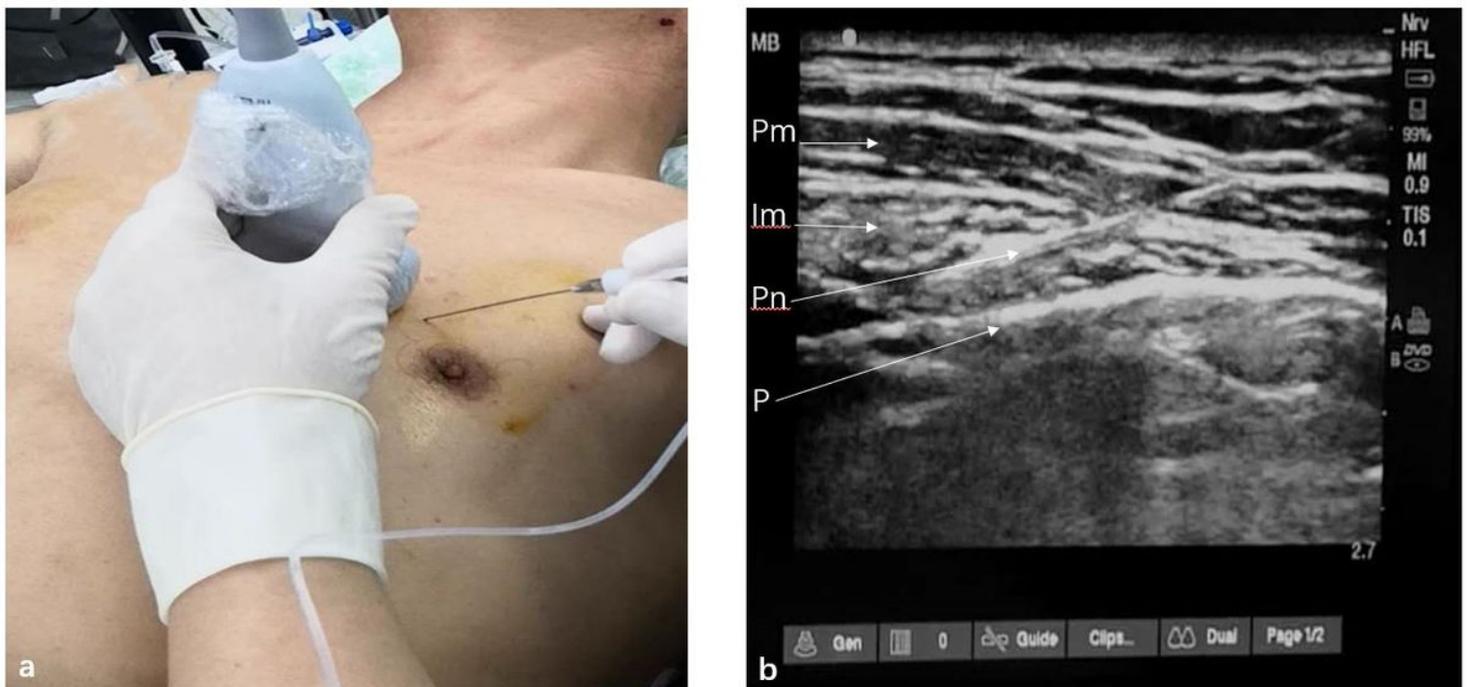


Figure 1

parasternal intercostal nerve block procedure. (a) The needle and probe position, (b) ultrasonographic image of parasternal space. Pm: Pectoralis major; Im: Intercostal muscle; Pn: Puncture needle; P: Pleura

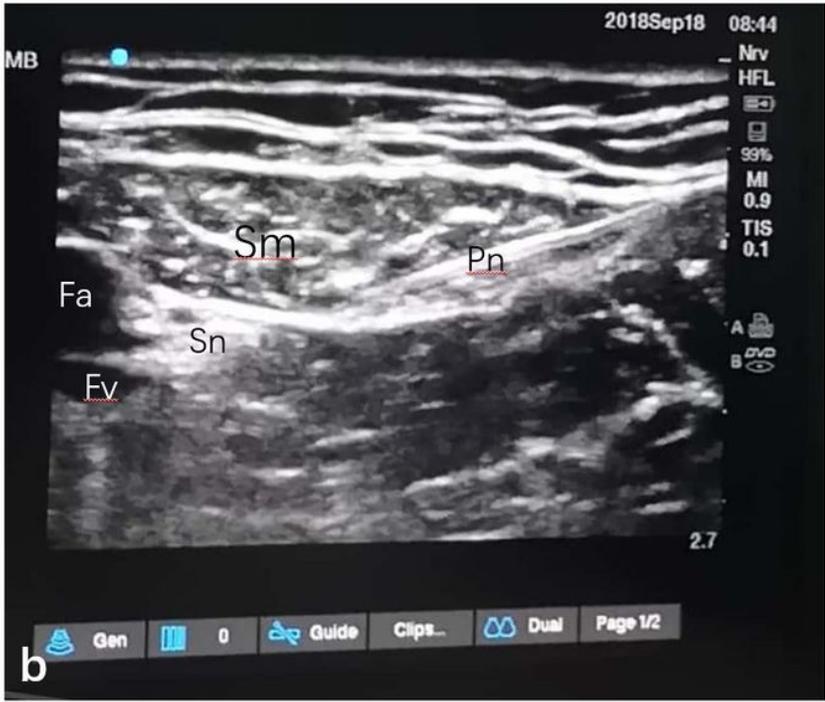


Figure 2

saphenous nerve block procedure. (a) The needle and probe position, (b) ultrasonographic image. Sm: Sewing muscle; Sn: Saphenous nerve; Fa: Femoral artery; Fv: Femoral vein; Pn: Puncture needle

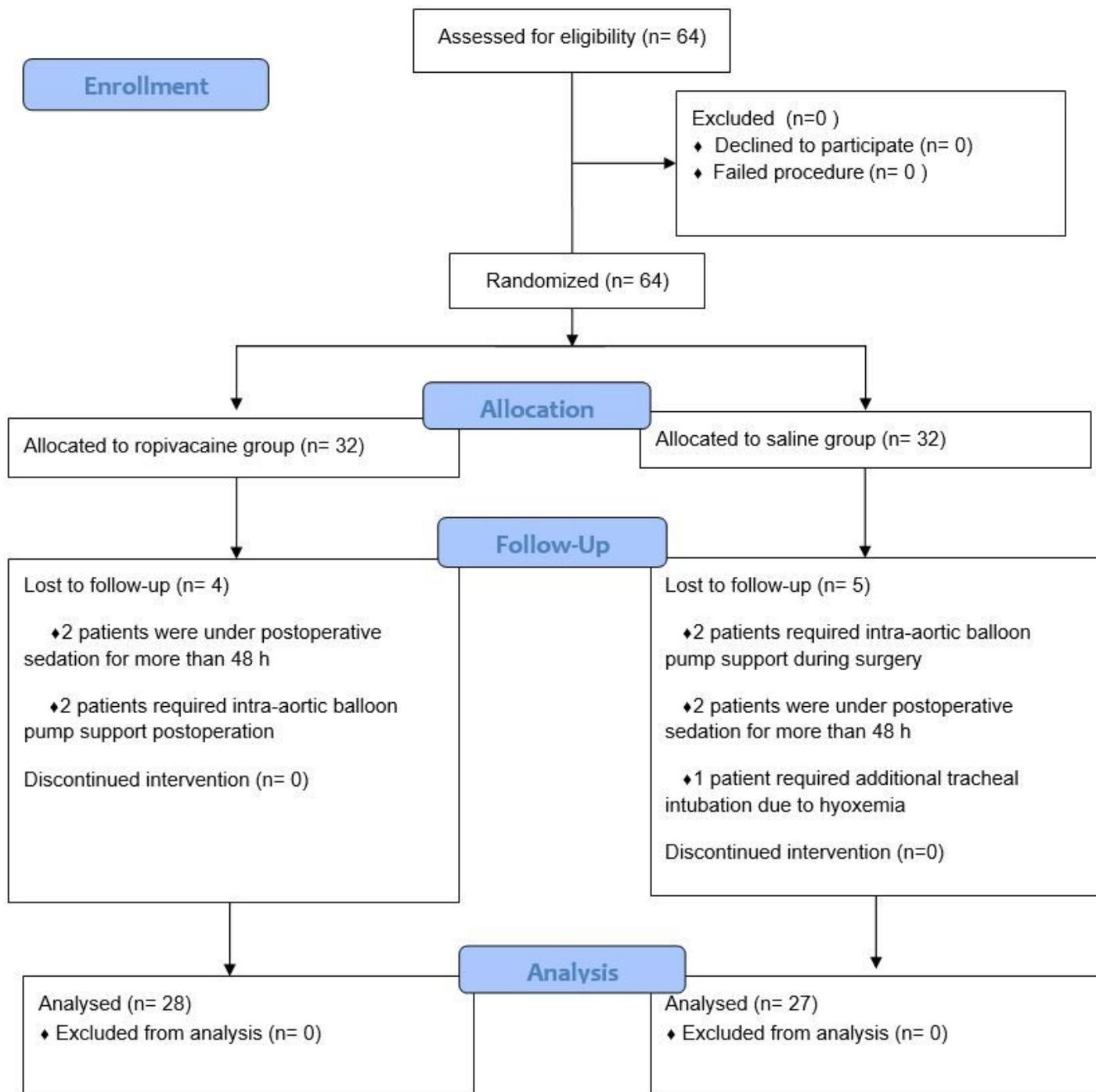
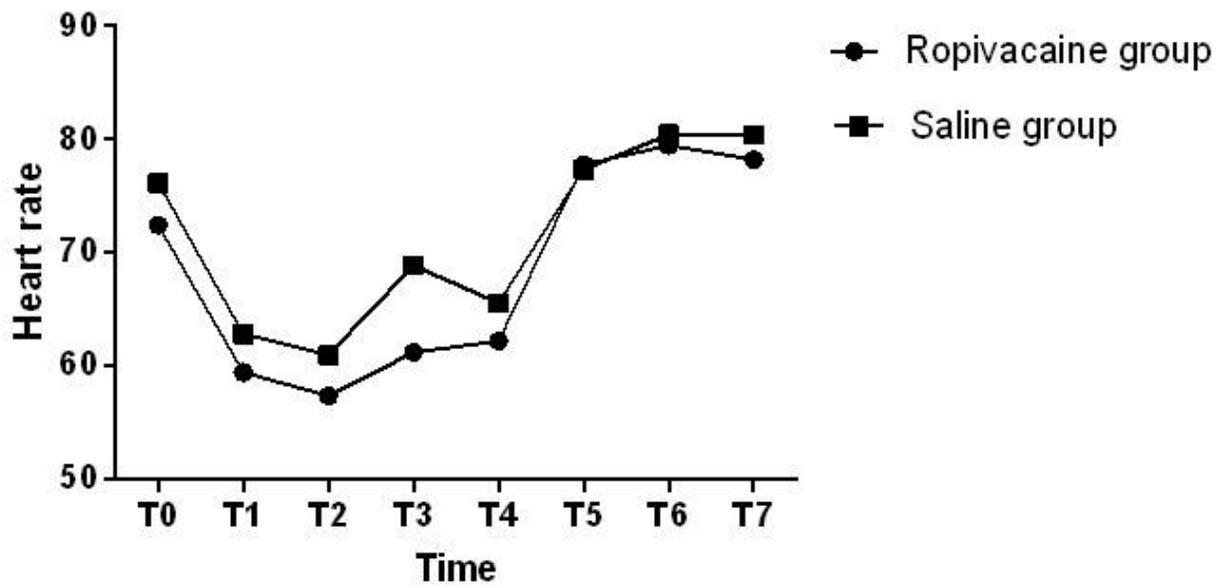
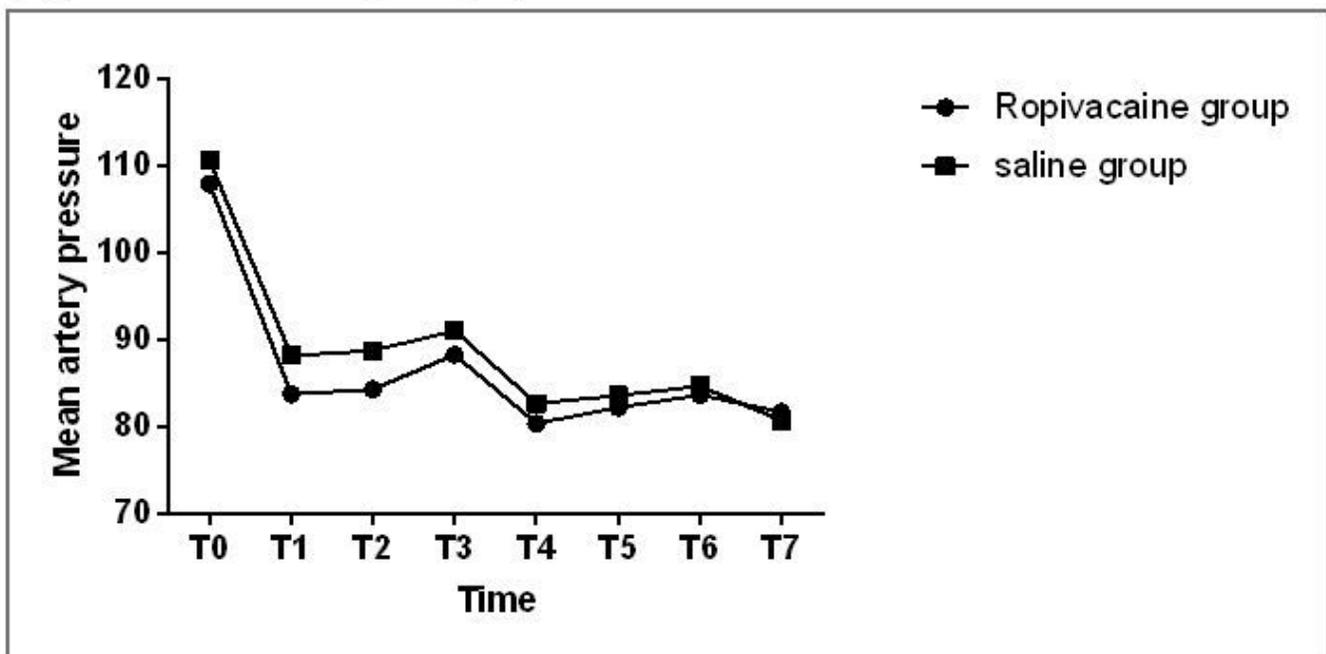


Figure 3

CONSORT Flow diagram



(A) Heart rate during surgery



(B) Mean artery pressure during surgery

Figure 4

. Heart rate(A) and mean artery pressure(B) with time between two study groups. T0: entering operation room, T1: before skin incision, T2: 1 min after skin incision, T3: 1 min after median sternotomy, T4: after dissection of IMA, T5: 5 min after reperfusion, T6: closure of sterno, T7: at the end of surgery.

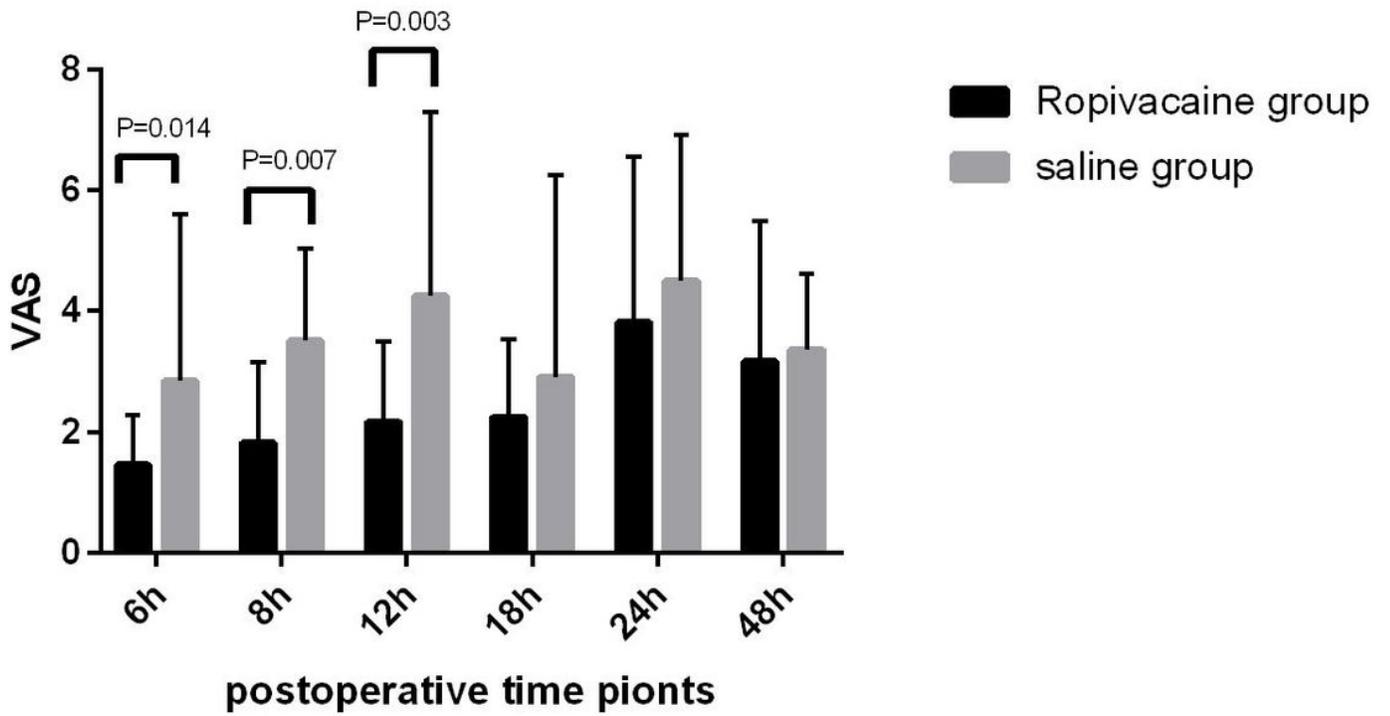


Figure 5

mean and SD for postoperative pain assessed with the VAS

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