

Efficacy of ultrasound-guided pect-intercostal fascial block in adult cardiac surgery: A meta-analysis of a randomized controlled trial

Bai Ronghua¹, Liang Yu¹, Gong Huaqu^{1,*}

¹Department of Anesthesiology, The General Hospital of Western Theater Command, Chengdu, Sichuan, 610083, China

447934265@qq.com

*Corresponding author: 494919507@qq.com

Abstract: In this paper, systematic review and meta-analysis are used to evaluate the role of pecto-intercostal fascial block (PIFB) in multimodal analgesia after cardiac surgery. Computer search PubMed, Embase, the Cochrane Library, CNKI, Wanfang and other Chinese and English databases. A randomized controlled trial (RCT) study comparing PIFB and a control group (without nerve block) for postoperative analgesia after cardiac surgery, published in Chinese and English, from database establishment to March 2024. According to the Cochrane manual, literatures were selected, data were extracted, methodological quality of the included literatures was evaluated, and meta-analysis was performed using RevMan5.4. Finally, 3 RCTS were included, with a total of 179 patients. Compared with the control group, the experimental group can reduce the resting pain score at 4h (MD=-1.89; 95%CI -2.10 ~ -1.67, P<0.00001), 8h (MD=-1.43; 95% CI-1.67 ~ -1.18, P<0.00001), 12h (MD=-1.35, P=0.02). 95% CI-1.53 ~ -1.16, P<0.00001) and 24h (MD=-0.45; 95%CI -0.69 ~ -0.21, P=0.0002) after cardiac surgery, the exercise pain score at 12h (MD=-0.93; 95%CI -1.18 ~ -0.69, P<0.00001) after surgery, and reduce the intraoperative sufentanil consumption (MD=-18.44; 95%CI -22.45 ~ -14.43, P<0.00001), postoperative extubation time (MD=-46.06; 95%CI -58.62 ~ -33.51, P<0.00001) and postoperative ICU stay time (MD=-3.47; 95%CI -4.85 ~ -2.09, P<0.00001). There was no significant difference in the total hospitalization time (MD=-0.30; 95%CI -0.65 ~ 0.05, P=0.09) between the two groups. Adding PIFB in postoperative multimodal analgesia can effectively control postoperative pain, reduce intraoperative opioid consumption, and help patients recover quickly after surgery.

Keywords: Ultrasound; pecto-intercostal fascial block; cardiac surgery; analgesia; Meta analysis

1. Introduction

Cardiac surgery often use median sternal incision, postoperative pain, pain control can activate the sympathetic nervous system, cause stress response, a variety of hormone release increase [1], can increase hypoxemia, atelectasis, myocardial ischemia, cerebrovascular accident, wound healing delay, deep vein thrombosis and the risk of postoperative hospitalization [2-3], is not conducive to postoperative rehabilitation. In recent years, the use of fascial plane block in postoperative analgesia has become more widespread, and more and more anesthesiologists are choosing to use fascial plane block as a multimodal analgesia management strategy[4]. The intercostal nerve travels between the most internal intercostal muscles and the internal intercostal muscles, and its anterior dermal branch penetrates the muscle tissue near the sternum to distribute on the skin surface, innervating the paraspinal and medial mammary regions. The pectointercostal fascial block (PIFB) injects a local anesthetic between the pectoralis major and intercostal muscles adjacent to the sternum to block the anterior cutaneous branch of the intercostal nerve, providing analgesia to the sternum, overlying skin, and soft tissues. With the development of ultrasound technology, PIFB, as an emerging fascial plane block technique, has been gradually applied to intraoperative anesthesia and postoperative analgesia with its advantages of good analgesic effect, high safety and simple operation. General anesthesia combined with PIFB can reduce the amount of intraoperative opioids, thereby reducing opioid-related adverse reactions and accelerating the recovery of patients after surgery. Therefore, the present study was designed to conduct a meta-analysis of completed randomized controlled trials (RCTs) at home and abroad, and to screen the literature that meets the quality standards, with the aim of systematically evaluating and comparing the analgesic effects and adverse effects of PIFB with those of general anesthesia alone in patients undergoing cardiac surgery, in

order to provide a reference basis for the clinic.

2. Data and methods

2.1 Search strategy

Based on PRISMA principles, the analgesic effect and rapid recovery of ultrasound-guided pect-intercostal fascial block (PIFB) after cardiac surgery were systematically reviewed. Two researchers independently searched English databases such as PubMed, Embase, Ovid, Web of Science and Cochrane Library, and Chinese databases such as CNKI, Vipp, Wanfang and China Biomedical full-text Database. Find published randomized controlled studies comparing analgesia and rapid recovery after cardiac surgery with PIFB. The search time was from the establishment of each database to March 2024. The English search terms included "pect-intercostal fascial block, PIFB, Heart surgery"; The Chinese search terms included "ultrasound, B-ultrasonography, chest intercostal fascia block and cardiac surgery". All searches use the combination of subject words and free words, and manually search the references of the obtained documents to avoid omissions.

2.2 Inclusion and exclusion criteria

Inclusion criteria :(1)RCT; (2) Patients who have undergone heart surgery and are at least 18 years old; (3) The experimental group received PIFB, but the control group did not receive any nerve block; (4) The main outcome indicators were the pain scores of resting state at 4h, 8h, 12h and 24h and the pain scores of exercise state at 12h after surgery; Secondary outcome measures were intraoperative sufentanil dose, postoperative extubation time, postoperative ICU stay, and total hospital stay.

Exclusion criteria :(1) Duplicate published studies; (2) Studies in which the full text or the required raw data is not available; (3) Other nerve blocks were used as postoperative analgesic measures in the control group; (4) Case reports, reviews or conference papers.

2.3 Literature screening and data extraction

Two researchers will independently screen relevant literature according to inclusion and exclusion criteria and extract basic data of each included study according to the pre-extraction table. If there is any disagreement, it will be discussed and resolved first. If no agreement can be reached, the third party will be consulted for settlement.

2.4 Quality evaluation

The methodological quality of the included literature was independently assessed by 2 researchers using the bias risk assessment tools recommended in the Cochrane Manual of Systematic Evaluators. The evaluation criteria included random sequence generation, assignment hiding, blind implementation, outcome data integrity, selective reporting, and other bias.

2.5 Statistical Methods

Meta-analysis was performed using RevMan5.4. The statistical data were expressed by the relative risk ratio (RR) and 95%CI. Measurement data were expressed using mean difference (MD) or standardized mean difference (SMD) and their 95%CI. First, the heterogeneity of the included study group was tested, and the test level $\alpha=0.1$ (single tail). If $P \geq 0.1$ and $P < 50\%$, a fixed effect model was used for meta-analysis. If $P < 0.1$ and $P \geq 50\%$, a random effects model was used for meta-analysis. The source of heterogeneity is analyzed, and the factors that may lead to heterogeneity are analyzed. If necessary, sensitivity analysis was used to check the stability of the results.

3. Results

3.1 Literature search results

Eleven literatures were initially retrieved, and 3 literatures were finally included after layer by layer screening, with a total of 179 patients. See Figure 1.

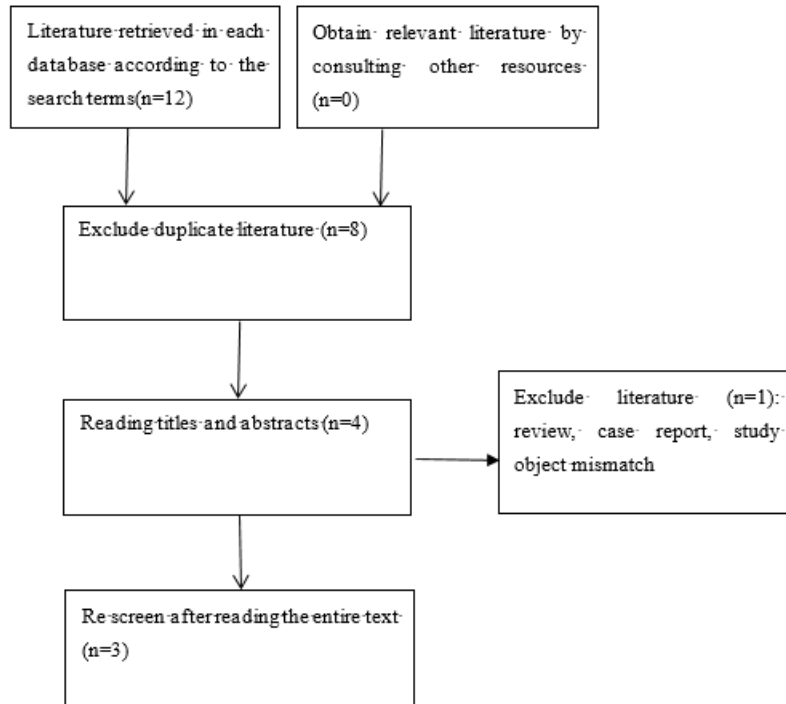


Figure 1: Literature Screening Process

3.2 Basic information and bias risk assessment of included literature

The basic characteristics of the included literature are shown in Table 1; The risk assessment of literature bias is shown in Figure 2.

Table 1: Basic characteristics of included studies

literature	sample size		Age (years)		Gender (male/female)		BMI(kg/cm ²)		ASA classification (Level II/III)		Surgical time (min)		Local anesthetic dosage		Outcome indicators	
	PIF group	Control group	PIF group	Control group	PIF group	Control group	PIF group	Control group	PIF group	Control group	PIF group	Control group	PIF group	Control group	PIF group	Control group
Liu XQ 2020 [5]	30	30									180±25	183±28	0.375% ropivacaine 20ml		1-2, 4, 6-9	
Luo JL 2023 [6]	19	20	63.4±10.9	59.8±10.9	6/13	7/13	24.0±1.5	21.5±4.3	8/11	8/12	330.0±25.5	301.7±37.5	0.375% ropivacaine 20ml		3-9	
Fang ZJ 2024 [7]	40	40	63.9±8.7	64.2±9.2	23/17	22/18	24.7±2.6	23.9±3.2	5/35	6/34	217.5±39.0	219.7±40.1	0.25% ropivacaine 30ml		1-3, 5-9	

1, 2, 3 and 4 were resting pain scores at 4h, 8h, 12h and 24h, respectively. 5 was the pain score of exercise state 12h after operation, 6: Intraoperative sufentanil usage, 7 is the postoperative extubation time; 8 is the postoperative ICU stay time; 9 is the total length of hospitalization.

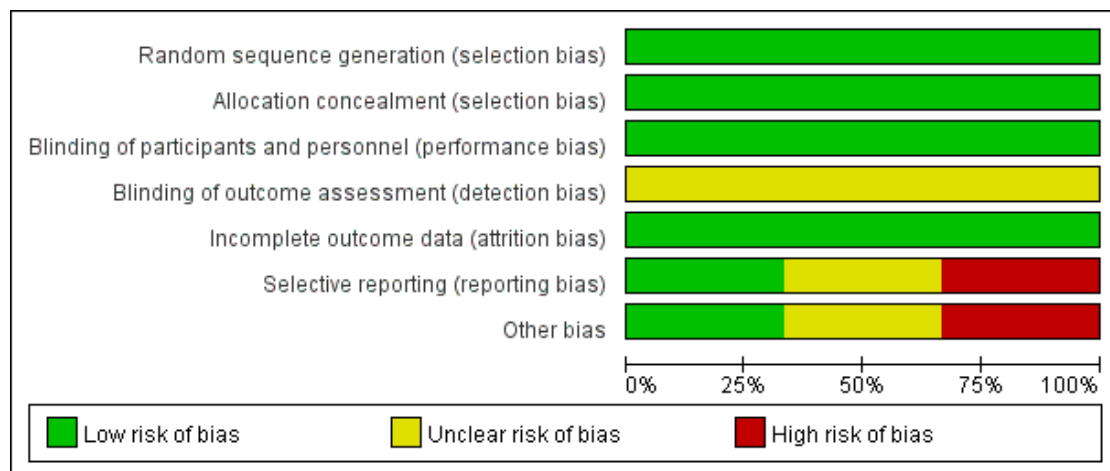


Figure 2: Bias Risk Assessment Chart

3.3 Results of meta-analysis

3.3.1 Resting state pain scores of patients in the two groups at different time points after surgery

Two literatures [5,7] compared the resting pain score at 4 h after surgery, showing significant heterogeneity ($I^2=98\%$, $P<0.00001$). Using the random effects model, the results of meta-analysis showed that the resting pain score at 4 h after surgery in the test group was significantly lower than that in the control group (MD=-1.89; 95%CI -2.10 ~ -1.67, $P<0.00001$) (Figure 3-A). Two literatures [5,7] compared the resting pain score at 8h after surgery, showing significant heterogeneity ($I^2=92\%$, $P=0.0003$). Using the random effects model, the results of meta-analysis showed that the resting pain score at 8h after surgery in the test group was significantly lower than that in the control group (MD=-1.43; 95% CI-1.67 ~ -1.18, $P<0.00001$) (Figure 3-B). Two literatures [6-7] compared the resting pain score at 12h after surgery, showing significant heterogeneity ($I^2=83\%$, $P=0.02$). Using the random effects model, the results of meta-analysis showed that the resting pain score at 12h after surgery in the test group was significantly lower than that in the control group (MD=-1.35, $P=0.02$). 95% CI-1.53 ~ -1.16, $P<0.00001$) (Figure 3-C). Two literatures [5-6] compared 24h postoperative resting state pain scores without significant heterogeneity ($I^2=0\%$, $P=0.47$). Using the fixed-effect model, meta-analysis results showed that 24h postoperative resting state pain scores in the test group were significantly lower than those in the control group (MD=-0.45; 95%CI -0.69 ~ -0.21, $P=0.0002$) (Figure 3-D).

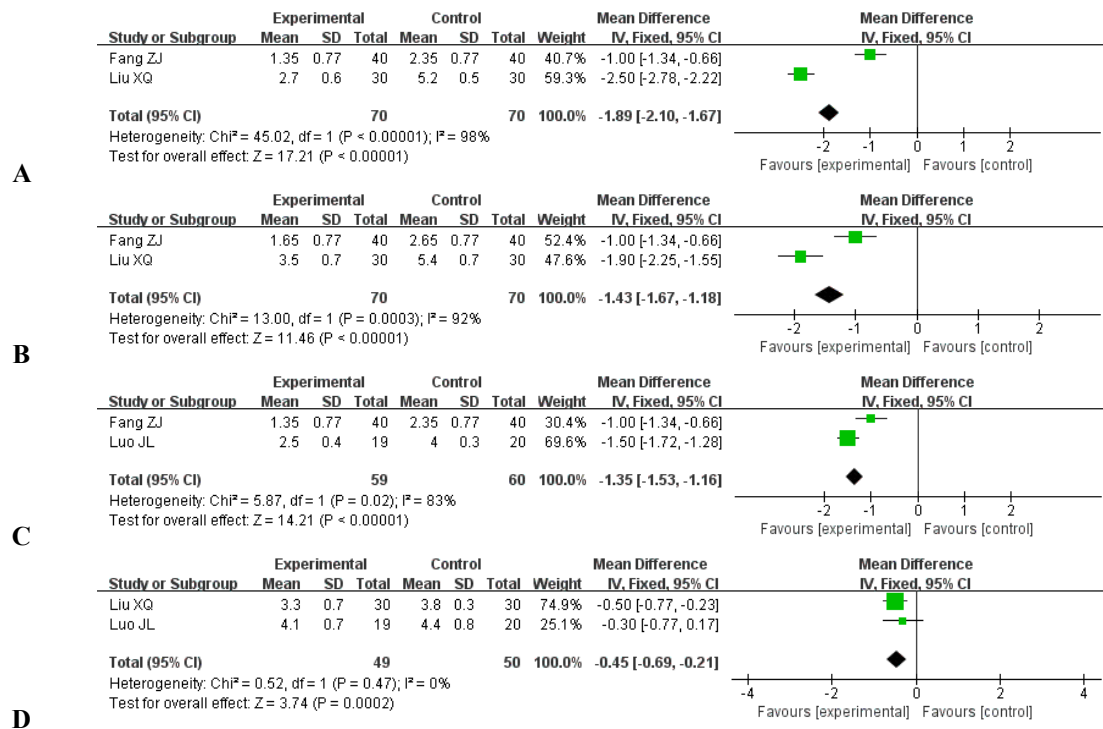


Figure 3: Resting state pain scores at different time points after surgery

3.3.2 Pain scores of exercise state 12h after operation in both groups

Two literatures [6-7] compared the exercise pain score at 12 h after surgery, showing significant heterogeneity ($I^2=96\%$, $P<0.00001$). Using the random effects model, the results of meta-analysis showed that the the exercise pain score at 12 h after surgery in the test group was significantly lower than that in the control group (MD=-0.93; 95%CI -1.18 ~ -0.69, $P<0.00001$) (Figure 4).

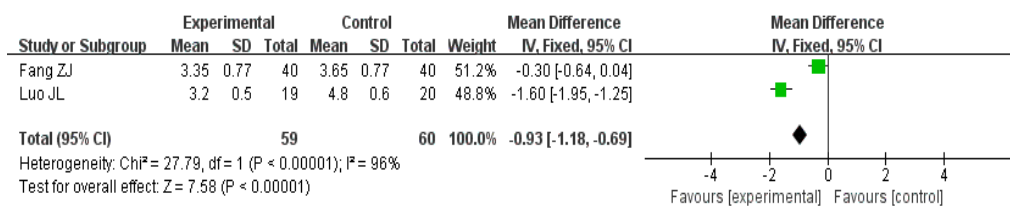


Figure 4: Pain scores of exercise state 12h after operation in both groups

3.3.3 Intraoperative dose of sufentanil used in two groups

Three literatures [5-7] compared the intraoperative dose of sufentanil used, showing significant heterogeneity ($I^2=97%$, $P<0.00001$). Using the random effects model, the results of meta-analysis showed that the intraoperative dose of sufentanil used in the test group was significantly lower than that in the control group (MD=-18.44; 95%CI -22.45 ~ -14.43, $P<0.00001$) (Figure 5).

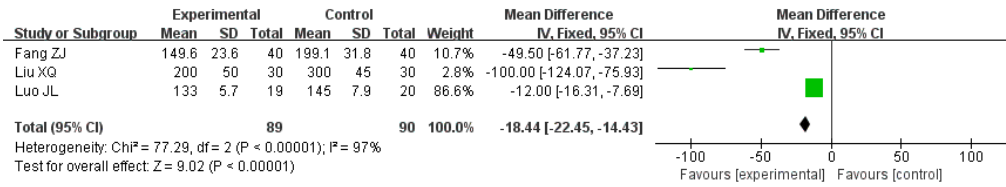


Figure 5: Intraoperative dose of sufentanil used in two groups

3.3.4 Indicators associated with rapid recovery after surgery

Three literatures [5-7] compared the postoperative extubation time, showing significant heterogeneity ($I^2=90%$, $P<0.00001$). Using the random effects model, the results of meta-analysis showed that the postoperative extubation time in the test group was significantly lower than that in the control group (MD=-46.06; 95%CI -58.62 ~ -33.51, $P<0.00001$) (Figure 6-A). Three literatures [5-7] compared the postoperative ICU stay time, showing without significant heterogeneity ($I^2=82%$, $P=0.07$). Using the fixed effects model, the results of meta-analysis showed that the postoperative ICU stay time in the test group was significantly lower than that in the control group (MD=-3.47; 95%CI -4.85 ~ -2.09, $P<0.00001$) (Figure 6-B). Three literatures [5-7] compared the total hospitalization time, showing without significant heterogeneity ($I^2=43%$, $P=0.17$). Using the fixed effects model, the results of meta-analysis showed that there is no significant difference in the total hospitalization time between the two groups of patients (MD=-0.30; 95%CI -0.65 ~ 0.05, $P=0.09$) (Figure 6-C).

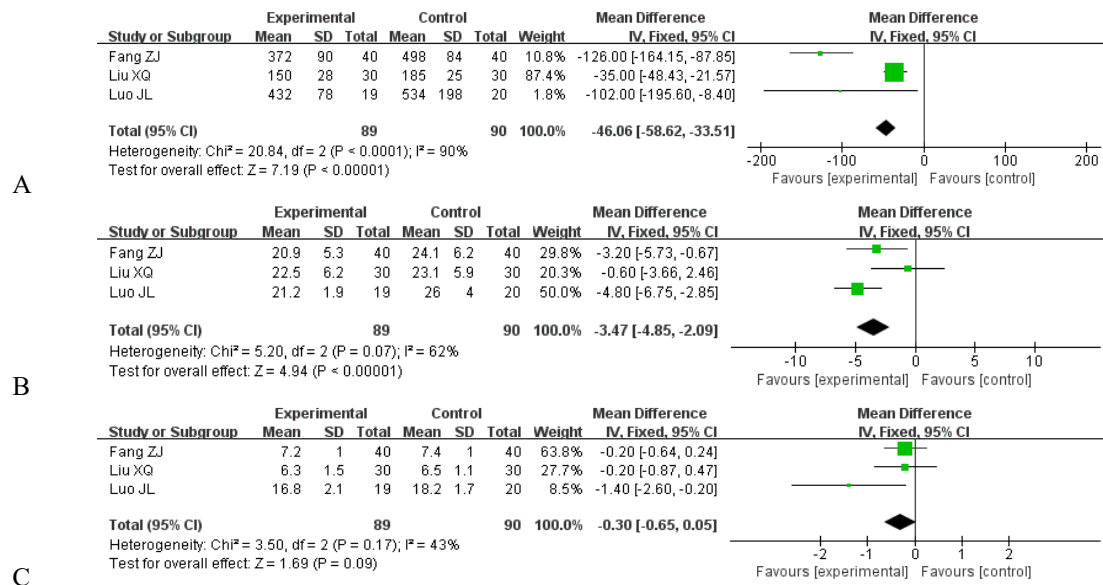


Figure 6: Indicators associated with rapid recovery after surgery

3.3.5 Publication bias

A funnel plot was drawn based on the postoperative ICU stay time. The funnel plot was symmetrically distributed, and the results indicated a relatively large publication bias. (Figure 7)

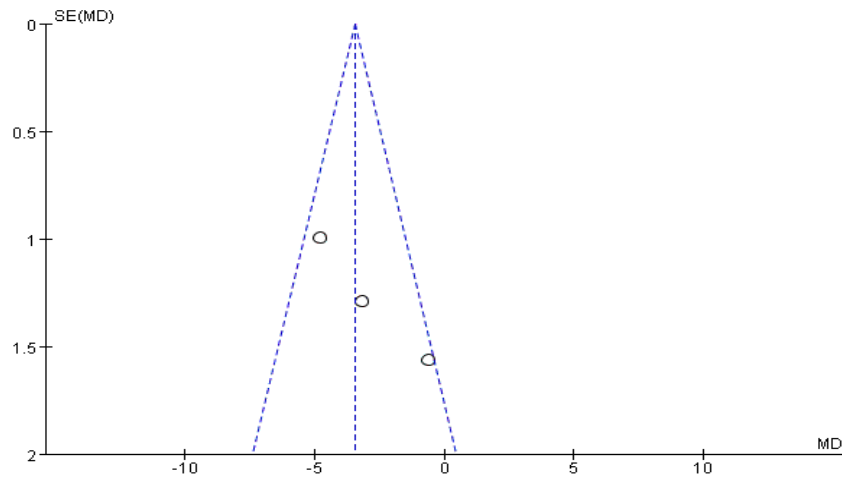


Figure 7: Funnel plot of publication bias in postoperative ICU stay time

4. Discussion

The number of patients undergoing direct cardiac surgery continues to increase each year worldwide. Patients undergoing open heart surgery may experience severe acute post sternotomy pain, with 35% of patients experiencing persistent pain within 1 year after surgery [8]. Post sternotomy pain can lead to decreased patient satisfaction, cardiovascular complications (hypertension, tachycardia, arrhythmias), hyperglycemia, and respiratory complications (bronchial secretion stasis and pneumonia) [9]. Self-controlled analgesia via intravenous opioids is most commonly used to relieve pain after cardiac surgery; however, opioids can cause adverse effects including delayed tracheal extubation, respiratory depression, nausea, vomiting, immunosuppression, cough suppression, and increased risk of chronic pain [10]. Epidural anesthesia and paravertebral block can provide effective analgesia by early extubation and reduced opioid use in cardiac surgery patients, to spinal sympathectomy causing hypotension, and destructive epidural hematomas after heparinization limit their use in cardiac surgery [11]. In contrast, the use of PIFB in patients undergoing cardiac surgery ignores the relevant constraints and has the advantage of avoiding pneumothorax and vascular injury [12].

After the first use of ultrasound-guided PIFB for analgesia in breast surgery by De La Torre et al [13], the technique has become increasingly popular for procedures on the anterior chest wall. PIFB injects local anesthetic between the pectoralis major and intercostal muscles adjacent to the sternum, targeting the anterior branch of the intercostal nerve adjacent to the T2-T6 dermatomal distribution, to provide analgesia for the anterior chest wall innervated by the anterior dermatomal branch. PIFB can be successfully used for implantable cardioverter-defibrillator implantation, repair of sternal wounds, and pain management of thoracic gland surgery through median sternal incision [14-16]. and there are also case reports of using PIFB after coronary artery bypass grafting to successfully control pain that is not treated with opioids and other analgesic drugs [17]. PIFB is superficially located, with a simple and clear ultrasonographic image. It has similar efficacy and high clinical safety [18-19]. Compared with the intercostal nerve block with multipoint injection, PIFB can reduce the risk of chest wall and intercostal nerve injury.

The results of this Meta-analysis suggest that compared with patients under general anesthesia alone, patients in the general anesthesia combined with PIFB group had significantly lower resting pain scores at 4h, 8h, and 12h postoperatively; and motor pain scores also decreased significantly at 12 and 24h postoperatively, indicating that ultrasound-guided PIFB can significantly alleviate postoperative pain in patients with median-open chest. Sufentanil is most commonly used in cardiac surgery, which has stabilized hemodynamics and effective postoperative analgesia; however, sufentanil can cause adverse effects, including respiratory depression, sedation, nausea, and increased ICU stay [20]. General anesthesia combined with PIFB reduced perioperative sufentanil dosage, increased analgesia, and there was no increase in associated adverse events. We also compared the patients' rapid recovery indicators such as postoperative tracheal tube removal time, and the results showed that the mean time to extubation was significantly lower in the general anesthesia combined with PIFB group, and the reduction in ICU hospitalization time was probably due to the use of minimal amounts of sufentanil. Therefore, the minimal use of sufentanil in the PIFB group may be an important component in promoting recovery from

direct cardiac surgery.

5. Conclusions

In summary, the results of the analysis of this study suggest that, compared with patients applying general anesthesia alone, the resting state pain scores of cardiac surgery patients in the ultrasound-guided PIFB group were significantly reduced in the early postoperative period (4h, 8h, and 12h postoperatively), and the motor pain scores were also significantly reduced at 12 and 24h postoperatively, and in the meantime the perioperative opioid dosage was also significantly reduced, although the total hospital stay of the patients was not difference, but shortened extubation time and ICU hospitalization time, so ultrasound-guided PIFB combined with general anesthesia can significantly improve the postoperative analgesic effect of cardiac surgery, improve the quality of patients' postoperative recovery, and promote the early recovery of patients.

The following shortcomings exist in this systematic evaluation study: (1) some of the studies included in the literature were not identical in terms of anesthesia regimen, ultrasound localization and imaging methods, local anesthetic concentration and dose, which may increase clinical heterogeneity; (2) there are relatively few high-quality papers included in the literature; (3) the pain level was assessed differently among the studies, which may have caused measurement bias; and (4) the funnel plot suggests that a possible publication bias exists. Combined with the above shortcomings, the conclusions of this study need to be validated by multicenter, large-sample, and high-quality RCTs due to the limitation of the number of original studies.

References

- [1] Huang AP, Sakata RK. Review of pain-after sternotomy. *Chinese Journal of Anesthesiology*[J]. 2016,66(4):395-401.
- [2] Eremenko AA, Zyulyaeva TP. Postoperative acute respiration Heart surgery failed[J]. *Journal of Harbin Institute of Technology*, 2019, (8):5-11.
- [3] Javaherforooshzadeh F, Abdalbeygi H, Janatmakan F, et al. Comparing the effects of ketorolac and paracetamol on postoperative pain relief after coronary artery bypass graft surgery. a randomized clinical trial[J]. *J Cardiothorac Surg*, 2020, 15(1): 80.
- [4] Jiang J, Ma DX, Wen H, et al. Ultrasound-guided thoracic myofascial gap block. *Progress of ultrasound-guided thoracic myofascial gap block*[J]. *Journal of Clinical Anesthesiology*, 2021, 37(2): 200 - 203.
- [5] Liu Xiaoqing, Ye Fengqing, Hu Yanyan, et al. Guided by ultrasound between bilateral chest rib under the fascia block in the application of cardiac surgery [J]. *Chinese journal of cardiology*, 2020, 20 (01) : 3209-3211.
- [6] Luo Jialin. Effect of ultrasound-guided thoracic intercostal fascia block on perioperative analgesia in patients undergoing cardiac surgery [D]. *Dalian medical university*, 2023.
- [7] Fang Zhaojing, Zhang Yong, Wang Xiaoliang, et al. Effect of thoracic intercostal fascia block on early recovery quality after cardiac valve replacement [J]. *Journal of Clinical Anesthesiology*, 2019,40(03):243-247.
- [8] Wang Xuedong, Shi Chengmei, Li Min. Perioperative analgesia modalities in minimally invasive cardiac surgery[J]. *Chinese Journal of Minimally Invasive Surgery*, 2019, 19(1): 69-72.
- [9] Gui Yun, Shang Yuqiang, Long Ding, et al. Analysis of risk factors for sternal incision infection after cardiac surgery[J]. *Chongqing Medicine*, 2019, 48(15): 167-169.
- [10] Hou, H., Liu, L., Ke, J., et al. Ultrasound-guided transversus abdominis plane block in laparoscopic radical nephrectomy[J]. *Journal of Clinical and Experimental Medicine*, 2019, 18(7): 101-104.
- [11] Jiang Shuai, Zhang Ruiying, Liu Fengqi, et al. Thoracic segmental epidural anesthesia in cardiovascular disease[J]. *Advances in Cardiovascular Disease*, 2019, 40(3): 385-388.
- [12] Wu Zupei, Chen Haoming. Study on the application of intrathoracic intercostal nerve block for intra- and postoperative analgesia in open thoracic surgery[J]. *Guangzhou Medicine*, 2019, 30(6): 25-26.
- [13] De La Torre PA, García PD, Álvarez SL, et al. A novel super-sound-guided block: a promising alternative for breast analgesia[J]. *Aesthetic Surg J*, 2014, 34(1): 198-200.
- [14] Droghetti A, Fusco P, Marini M, et al. Ultrasound-guided serratus anterior plane block and parasternal block in cooperative sedation for S-ICD implantation[J]. *Pacing Clin Electrophysiol*.2019, 42(7): 1076-1078.

- [15] Toscano A, Capuano P, Rinaldi M, et al. Successful use of single-shot pectointercostal fascial block for awake sternal wound revision[J]. *Ann Card Anaesth*, 2022, 25(3): 377-378.
- [16] Jones J, Murin PJ, Tsui JH. Opioid free postoperatively using pecto-intercostal fascial block (PIFB) with multimodal analgesia (MMA) in a patient with myasthenia gravis underwent thymectomy via sternotomy [J]. *J Clin Anesth*, 2020, 59: 32-33.
- [17] Liu V, Mariano ER, Prabhakar C. Pecto-intercostal fascial block for acute poststernotomy pain: a case report [J]. *A A Pract* 2018, 10 (12): 319-322.
- [18] Sepolvere G, Tognù A, Tedesco M, et al. Avoiding the internal mammary artery during parasternal blocks: ultrasound identification and technique considerations[J]. *J Cardiothorac Vasc Anesth*. 2021, 35(6): 1594 - 1602.
- [19] Kaya C, Dost B, Dokmeci O, et al. Comparison of ultrasound-guided pecto-intercostal fascial block and transversus thoracic muscle plane block for acute poststernotomy pain management after cardiac surgery: a prospective, randomized, double-blind pilot study. *J Cardiothorac Vasc Anesth*, 2022, 36 (8 Pt A):2313-2321.
- [20] Wen Xiaolin, Li Hezhi, Li Chaoming, et al. Effects of different doses of sufentanil on stress response, inflammatory factors and myocardial injury in patients undergoing heart valve replacement[J]. *Modern Biomedical Progress*, 2020, 20(1): 172- 176.