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The serratus anterior plane block for analgesia after thoracic surgery

A meta-analysis of randomized controlled trails

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Abstract

Background: The serratus anterior plane (SAP) block is a newer method that can be used in patients undergoing thoracic surgeries. The postoperative analgesia efficacy of SAP blocks for thoracic surgery remains controversial. We conduct a meta-analysis to evaluate the analgesia of SAP blocks after thoracic surgery.

Methods: We searched PubMed, Embase, EBSCO, the Cochrane Library, Web of Science, and CNKI for randomized controlled trials (RCTs) regarding the postoperative pain control of a SAP block on thoracic surgery. All of the dates were screened and evaluated by two researchers and meta-analysis was performed using RevMan5.3 software.

Results: A total of 8 RCTs involving 542 patients were included. The meta-analysis showed statistically significant differences between the two groups with respect to postoperative pain scores at 2 h (standardized mean difference [Std.MD] = −1.26; 95% confidence interval [CI] = −1.66 to −0.86; $P < .0001$); 6 h (SMD = −0.50; 95%CI = −0.88 to −0.11; $P = .01$); 12 h (SMD = −0.63; 95% CI = −1.10 to −0.16; $P = .009$); 24 h (SMD = −0.99; 95%CI = −1.44 to −0.51; $P < .0001$); postoperative opioid consumption at 24 h (SMD = −0.83; 95%CI = −1.10 to −0.56; $P < .00001$); and postoperative nausea and vomiting (PONV) rates (RR = 0.39; 95% CI = 0.21–0.73; $P = .003$).

Conclusion: The SAP block can play an important role in the management of pain after thoracic surgery by reducing both pain scores and 24-h postoperative opioids consumption. In addition, there is fewer incidence of PONV in the SAP block group.

Abbreviations: CI = confidence interval, PONV = postoperative nausea and vomiting, RCTs = randomized controlled trails, SAP = serratus anterior plane, SMD = standard mean difference.

Keywords: meta-analysis, pain scores, serratus anterior plane block, thoracic surgery

1. Introduction

Thoracic surgery is one of the common surgical procedures which lead to severe postoperative pain.[1] The study found that 31% of patients after thoracic surgery suffered from severe pain, and 47% experienced moderate pain.[2] With the development of thoracoscopy technology, although video-assisted thoracoscopic surgery (VATS) reduce postoperative pain because of its smaller incisions, pain control after thoracic surgery remain challenging.[3] Poor pain control after thoracic surgery is associated with increased length of stay and recovery, and it also has an influence on psychological changes, quality of life, and patient satisfaction.[4,5] Opioid-related side effects are in fact numerous, and include respiratory depression, itching, hypotension nausea and vomit, bowel ileus, confusion, and sedation.[6] Especially for the elderly patients, repeated high-dose use of opioids may lead to cognitive dysfunction and even coma. Thoracic epidural analgesia (TEA) is considered the gold standard technique for pain management after thoracic surgery,[1,2] but there is a need for adequate skilled care providers for its perioperative management, and it can cause sympathetic blockade, respiratory depression, urinary retention and, rarely, local complications both during and after procedure.[5]

In the past decade, there has been an increased interest in the use of regional nerve blocks for post-thoracic surgery analgesia.[7] This was especially related to the introduction of ultrasound guidance, which has facilitated the administration of a kind of plane blocks to achieve effective regional anesthesia. In 2013, the SAP block has been described by Blanco and colleagues.[8] At that time, it was mainly used for postoperative analgesia of breast cancer, and then gradually popularized in clinical application.[9] The SAP block was demonstrated to provide analgesia to the 2nd and 9th thoracic dermatomes by blocking the lateral cutaneous branches of the thoracic intercostal nerves passing through these

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The datasets generated during and/or analyzed during the present study are available from the corresponding author on reasonable request.

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planes.[8] The SAP block is safe and easy to perform, owing to its easy-to-learn technique and distinct bony landmarks. So it can be an attractive alternative for pain relief after thoracic surgery.[10] Several clinical trials[11,12] described using SAP blocks for thoracic surgery. However, no meta-analysis has demonstrated the effects of this block on postoperative analgesia undergoing thoracic surgery. The purpose of this study is to evaluate, in the form of meta-analysis, whether SAP blocks can be better used for postoperative pain management after thoracic surgery.

2. Materials and methods

The study was a meta-analysis, and ethical approval was not required. The review and meta-analysis was reported on the basis of Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA).

2.1. Search strategy

Two independent researchers performed the preliminary data search in PubMed, EMbase, EBSCO, the Cochrane Library, Web of science, and CNKI up to September 2019. The Medical Subject Headings (MeSH) and common keywords included "serratus anterior plane block" OR "SAP block" AND "thoracic surgery" OR "thoracotomy" OR "Video-assisted thoracic surgery" OR "VATS" OR "thoracoscopy." No restraints were set on the publication language.

2.2. Inclusion criteria and study selection

1. Population: Patients undergoing thoracic surgery (thoracotomy or thoracoscopy);
2. Study design: RCTs;
3. Interventions: SAP block;
4. Comparison: placebo (saline or no block);
5. The primary outcomes: pain scores at 4time points (postoperative hours 2, 6, 12, 24) and opioids consumption during postoperative hours 0 to 24; and
6. The secondary outcomes: PONV incidence.

Two reviewers searched and selected according to the above search strategy. Specific process:

1. Deduplicating retrieved references using endnote software;
2. Screening initially by reading literature titles and abstracts;
3. Reading the full texts of the screening results, selecting the eligible documents and conducting risk assessment for bias;
4. A third searcher had the final decision in case of any disagreement with respect to studies which included.

2.3. Data extraction

Two investigators extracted data from the included study, including the basic information (author name, number of cases, gender, age, type of surgery, and published year) of participants. The primary outcomes were pain scores and opioid consumption. The secondary outcome was PONV incidence. We also contacted the corresponding author to obtain the data when necessary.

2.4. Assessment of methodological quality

The methodological quality of RCT was evaluated by two searchers depended on the Cochrane Handbook and the third searcher had the final decision in case of any disagreement. The assessment involved random sequence generation, allocation scheme hiding, blinding, accuracy of data results, free of selective reporting, and other bias. The quality of the outcomes in meta-analysis was evaluated by the Grading of Recommendations Assessment, Development and Evaluation (GRADE) (Table 1).

2.5. Subgroup meta-analysis

Thoracic surgery was carried out by thoracotomy or VATS. The type of surgery performed will cause different results. Therefore, we performed a subgroup meta-analysis to assess postoperative pain scores at 6 and 12 h between the SAP block group and the control group with regard to the type of surgery.

Table 1

The GRADE evidence quality for main outcomes.

	Quality assessment					No of patients				
No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	SAP block groups	Control groups	Effect	Quality
Postoperative pain scores at 2 h										
3	RCT	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	90	90	SMD = −1.28 95%CI: (−1.83 to −0.74)	High
Postoperative pain scores at 6 h										
5	RCT	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	157	157	SMD = −0.99 95%CI: (−1.44 to −0.54)	High
Postoperative pain scores at 12 h										
4	RCT	No serious risk of bias	Serious	No serious indirectness	No serious imprecision	None	132	141	SMD = −0.63 95%CI: (−1.1 to 0.16)	Moderate
Postoperative pain scores at 24 h										
6	RCT	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	182	191	SMD = −0.50 95%CI: (−0.88 to −0.11)	High
Postoperative opioid consumption at 24 h										
3	RCT	No serious risk of bias	Serious	No serious indirectness	No serious imprecision	None	109	120	SMD = −0.83 95%CI: (−1.1 to −0.56)	Moderate

GRADE = Grading of Recommendations Assessment, Development, and Evaluation, RCT = randomized controlled trial, SAP = serratus anterior plane, SMD = standard mean difference.

2.6. Statistics analysis

The statistics analysis was gathered using RevMan5.3. We performed a heterogeneity test on the included studies and calculated the statistics. When $I^2 < 0.5$, or $P > .1$, few heterogeneity was indicated and a fixed-effects model was applied. Otherwise, a random-effects model was used. The continuous outcomes were calculated standardized mean difference (SMD) with 95% confidence interval (CI). Dichotomous outcomes were measured relative risk (RR) with 95% CI. Due to the limited number (<10) of included studies, publication bias was not evaluated.

3. Results

3.1. Literature search and study characteristics

A total of 278 relevant studies were initially detected, and 8 studies[13–20] were eventually included, with 542 patients. The study screening process and results were shown in Figure 1. The basic features of the 8 RCTs in meta-analysis were generalized in Table 2

3.2. Risk of bias

The Cochrane Handbook for Systematic Review of Interventions was used to evaluate risk of bias of the RCTs. Two studies[13,14] involved the means to use a random number table. Six studies[15–20] adopted the method of computer to generate random numbers. All studies[13–20] described the allocation concealment. Four studies[13–15,19] did not mention the blind method for the subjects. The researchers used the blind method as well as the rest. And there were five studies[14–17,20] made use of the blinding for outcome measurements and other three studies did not. In addition, all studies[13–20] reported the completion of the trial and no withdrawal. Two studies[13,14] reported other high biases. (Figs. 2 and 3)

3.3. Outcomes for meta-analysis

3.3.1. Postoperative pain scores at 2 h. Three studies[13–15] with 120 patients illustrated the pain scores at 2 h after thoracic surgery. A fixed-effects model was adopted because no heterogeneity was found among the researches ($I^2 = 0.46$, $P > .1$). There was significant difference in postoperative pain scores at 2 h between groups (Std.MD = −1.26; 95%CI = −1.66 to −0.86; $P < .00001$) (Fig. 4).

3.3.2. Postoperative pain scores at 6 h. Five studies[13–16,18,19] with 314 patients demonstrated the pain scores at 6 h after thoracic surgery. A random-effects model was applied because significant heterogeneity was found among the researches ($I^2 = 0.69$, $P < .1$). There was significant difference in postoperative

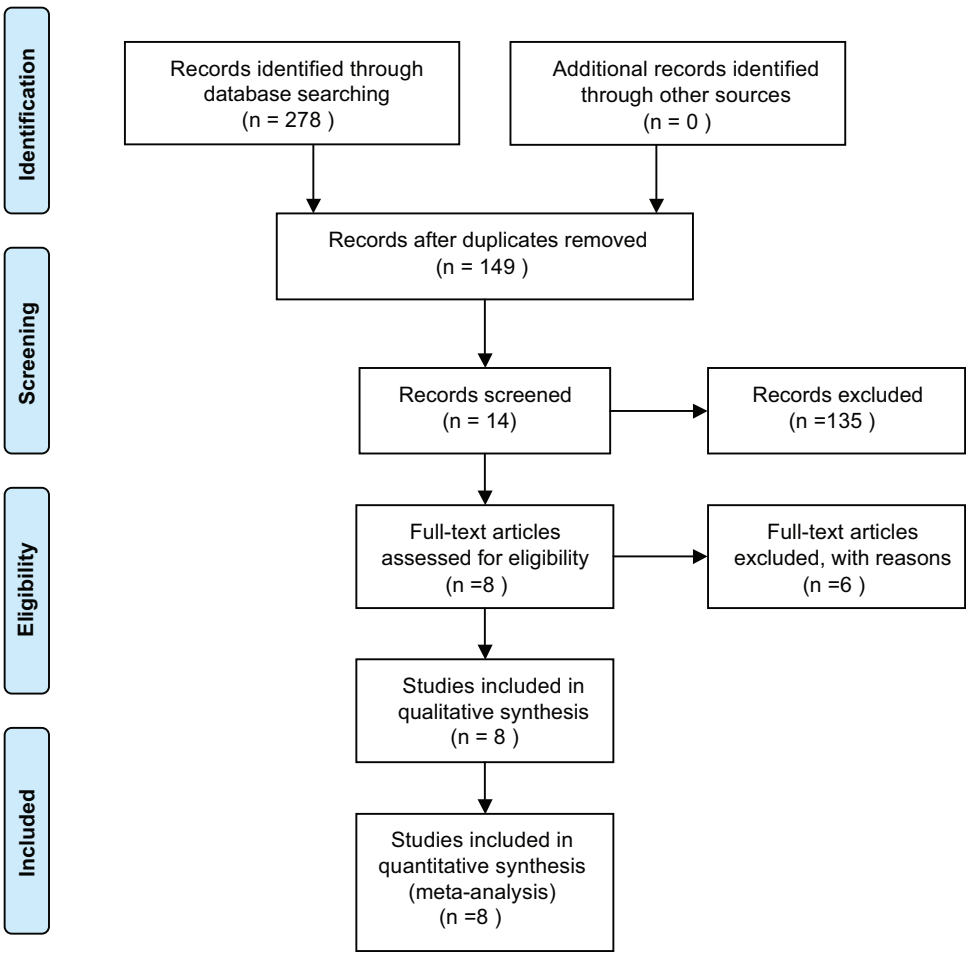

Figure 1. PRISMA flow diagram.

Table 2

Trails characteristics.

NO	Author	Research type	Location	ASA	Number (E/C)	Mean age (E/C)	SAP block group	Control group	Concomitant pain control	Surgery type
1	Reyad[16]	RCT	Egypt	II/III	45/44	47.4/49.1	A bolus of 20 mL of levobupivacaine at a concentration of 0.25% (0.125% levobupivacaine infusion at a rate of 7–12 mL/h)	NO block	Patient-controlled analgesia	Thoracotomy
2	Semyonov[18]	RCT	Isreal	II/II/III	47/57	62/56.1	A single injection of 0.25% bupivacaine hydrochloride 2 mg/kg	NO block	IV opioids, NASIDs and paracetamol	Thoracic surgery
3	Okmen[15]	RCT	Turkey	I/II/III	20/20	53.5/54.5	A single injection of 20 mL of bupivacaine at a concentration of 0.25%	NO block	Patient-controlled analgesia	VATS
4	Yu[14]	RCT	China	I/II/III	20/20	57.4/57.2	A single injection of 20 mL of ropivacaine at a concentration of 0.375%	Normal saline	Patient-controlled analgesia	VATS
5	Saad[19]	RCT	Egypt	I/II	30/30	52/55.1	A single injection of 30 mL of bupivacaine at a concentration of 0.5%	NO block	IV morphine	Thoracotomy
6	Kim[20]	RCT	Korea	I/II	42/43	56.4/54.1	A single injection of 30 mL of ropivacaine at a concentration of 0.375%	Normal saline	Patient-controlled analgesia	Video-assisted thoracic surgery
7	Zheng[13]	RCT	China	I/II	20/20	46/45	A single injection of 20 mL of ropivacaine at a concentration of 0.5%	Normal saline	Patient-controlled analgesia	VATS
8	Park[17]	RCT	Korea	I/II	42/42	58/58.4	A single injection of 15 mL of ropivacaine at a concentration of 0.375%	Normal saline	Patient-controlled Analgesia	VATS

C = controlled groups, E = experimental groups, IV = intravenous, NASIDs = Non-steroidal anti-inflammatory drugs, NO = number, RCT = randomized controlled trials, SAP = serratus anterior plane, VATS = Video-assisted thoracoscopic surgery.

pain scores at 6 h between groups (Std.MD = −0.5; 95%CI = −0.88 to −0.11; $P = .006$) (Fig. 5). In the subgroup analysis, in patients undergoing thoracotomy, there was no significant difference between the SAP block group and the control group (Std.MD = −0.17; 95%CI = −0.49 to −0.15; $P = .29$) (Fig. 5). In patients undergoing VATS, the postoperative pain scores at 6 h in the SAP block group was significantly lower than that in the control group (Std.MD = −0.72; 95%CI = −1.31 to −0.73; $P = .02$) (Fig. 5).

3.3.3. Postoperative pain scores at 12 h. Four studies[13,15,16,18] with 273 patients showed the pain scores at 12 h after thoracic surgery. A random-effects model was used because significant heterogeneity was found among the studies ($I^2 = 0.7$, $P < .1$). There was significant difference in postoperative pain scores at 12 h between groups (Std.MD = −0.63; 95%CI = −1.10 to −0.16; $P = .009$) (Fig. 6).

3.3.4. Postoperative pain scores at 24 h. Five studies[13,15,16,19,20] with 373 patients showed the pain scores at 24 h after thoracic surgery. A random-effects model was adopted because significant heterogeneity was found among the studies ($I^2 = 0.7$, $P < .1$). There was significant difference in postoperative pain scores at 24 h between groups (Std.MD = −0.99; 95%CI = −1.44 to −0.54; $P < .0001$) (Fig. 7). In the subgroup analysis, no source of heterogeneity was found. In patients undergoing thoracotomy, there was no significant difference between the SAP block group and the control group (Std.MD = −0.82; 95% CI = −1.83 to 0.19; $P = .11$) (Fig. 7) while in patients undergoing VATS, the postoperative pain scores in the VATS group was significantly lower than that in the control group (Std.MD = −1.10; 95%CI = −1.49 to −0.71; $P < .00001$) (Fig. 7).

3.3.5. Postoperative opioid consumption at 24 h. Three studies[13,17,19] with 229 patients showed the opioid consumption

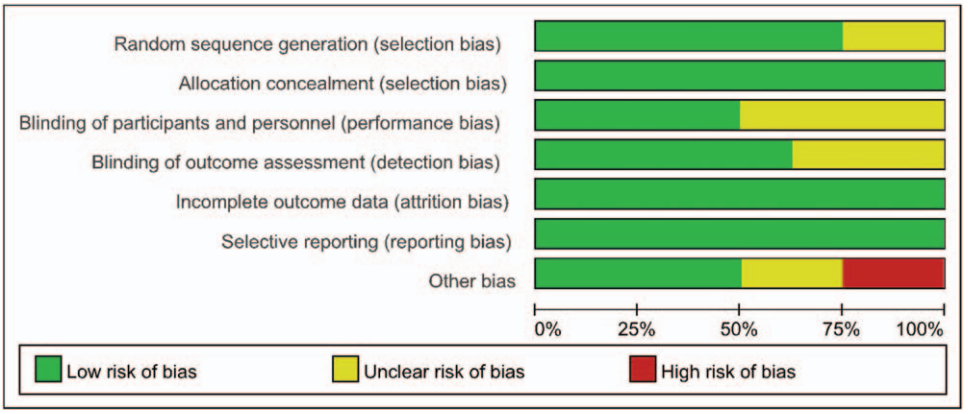

Figure 2. Risk of bias assessment of summary.

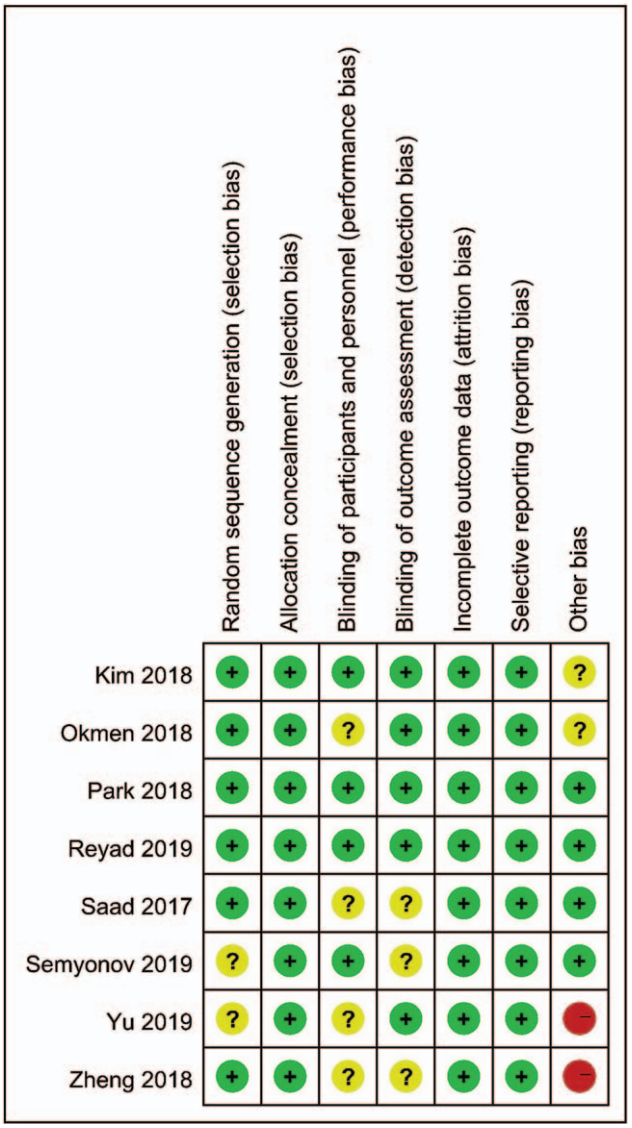

Figure 3. Risk of bias assessment of the studies.

at 24 h after thoracic surgery. A fixed-effects model was used because no heterogeneity was found among the studies ($I^2 = 0$, $P > .1$). There was a statistical difference in postoperative opioid consumption at 24 h between the 2 groups (Std.MD = −0.83; 95% CI = −1.10 to −0.56; $P < .00001$) (Fig. 8).

3.3.6. Postoperative nausea and vomiting. Five studies[14,15,17,18,20] with 353 patients showed the incidence of PONV. A fixed-effects model was used because no significant heterogeneity was found among the studies ($I^2 = 0$, $P < .1$). There was a significant difference in PONV between group (RR = 0.39; 95% CI = 0.21–0.73; $P = .0030$) (Fig. 9).

4. Discussion

This meta-analysis and systematic review of the literature is the first to evaluate the postoperative analgesic efficacy of SAP block after thoracic surgery. Based on 8 RCTs, the most interesting finding of the present meta-analysis is that SAP block can significantly reduce postoperative pain scores and opioid consumption after thoracic surgery. In addition, the incidence of PONV is lower in patients with SAP block.

Previously published meta-analyses reported that regional nerve block were effective in postoperative pain management after thoracic surgery.[3,21–23] Hu et al[24] reported that thoracic paravertebral (TPV) block was associated with substantially decreased pain scores and postoperative anesthesia consumption. In addition, the TPV block could improve patient rehabilitation and shorten hospital stay. Davies et al[25] showed that paravertebral block (PVB) and epidural analgesia provide comparable pain relief after thoracic surgery, but PVB has a better side-effect profile and was associated with a reduction in pulmonary complications. However, no meta-analysis has demonstrated the effects of this block on postoperative analgesia undergoing thoracic surgery. The benefits of SAP block for pain management in thoracic surgery remain controversial.

The SAP block is a new regional block technique for proving thoracic analgesia between the levels of thoracic 2 and 9, which was described by Blanco.[8] The SAP block was originally proposed for breast surgery but its applications have later been extended, and is now often used in thoracic surgery. Various studies have established that postoperative pain scores and additional opioids requirements and related adverse effects can be reduced by supplementing a multimodal analgesic regimen with a SAP block. Chu and Jarvis[26] reported that SAP block could provide effective pain control whenever the postoperative analgesia with unsatisfactory effects of TPV block, epidural anesthesia and intercostal nerve block. Park et al[6] found the SAP block reduced mean remifentanil dose during surgery and reduced mean fentanyl consumption in the first 24 postoperative hours, the block also reduced the severity of postoperative pain. However, some studies have found that a single SAP block could not provide sufficient analgesic time for thoracic surgery. Semyonov et al[18] suggested that the patients who received SAP block had significantly lower pain scores during only the first

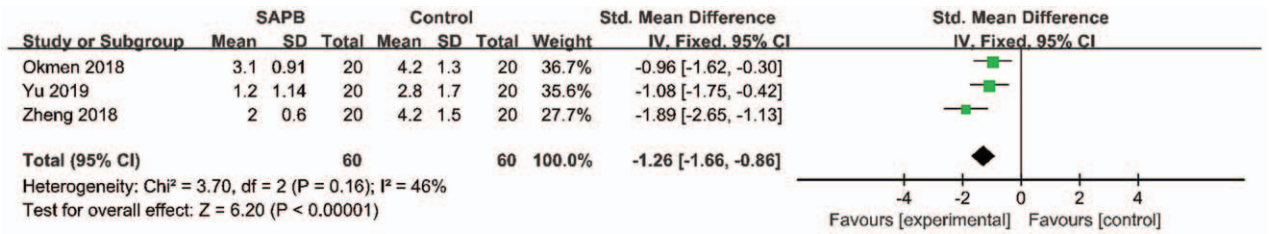

Figure 4. Forest plot for the meta-analysis of postoperative pain scores at 2 h.

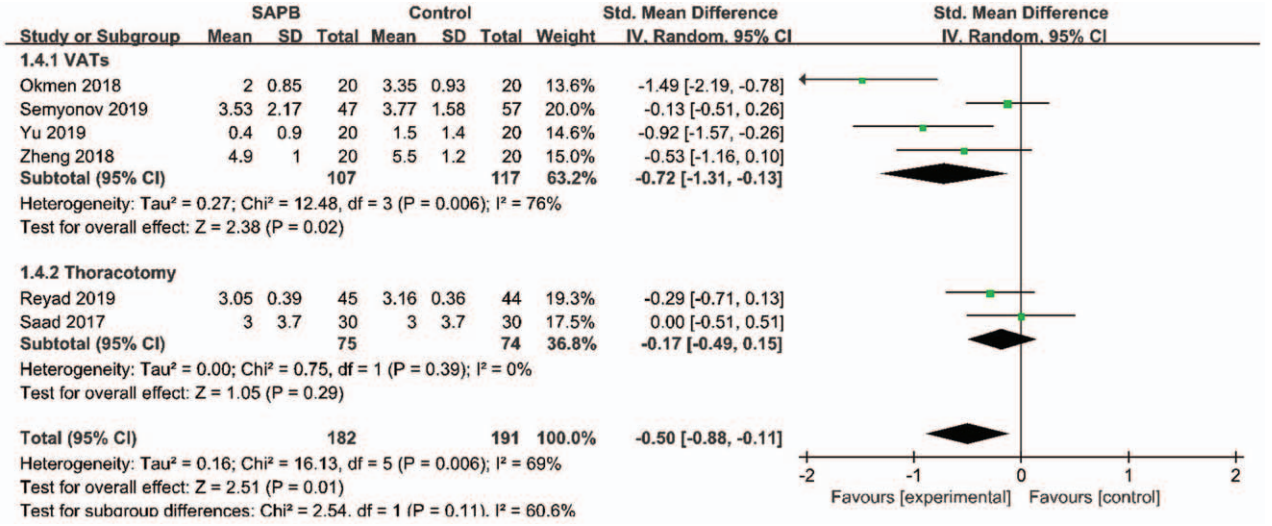

Figure 5. Forest plot for the meta-analysis of postoperative pain scores at 6 h.

8 postoperative hours, the 9 postoperative hour onward, there were no significant differences in the pain scores between the two groups. Okmen and Metin Okmen[15] assumed visual analog scale (VAS) scores at all measurement times were significantly lower in SAP group than in control group, and the amounts of patient-controlled intravenous analgesia (PCIA) tramadol consumption at the postoperative 24th hours were also found to be significantly lower in SAP group. There is no statistically significant difference in the incidence of PONV between the groups. Although a lot of studies have demonstrated that the SAP block was associated with pain relief in major thoracic surgery, there was sufficient of reliable evidence. The meta-analysis can

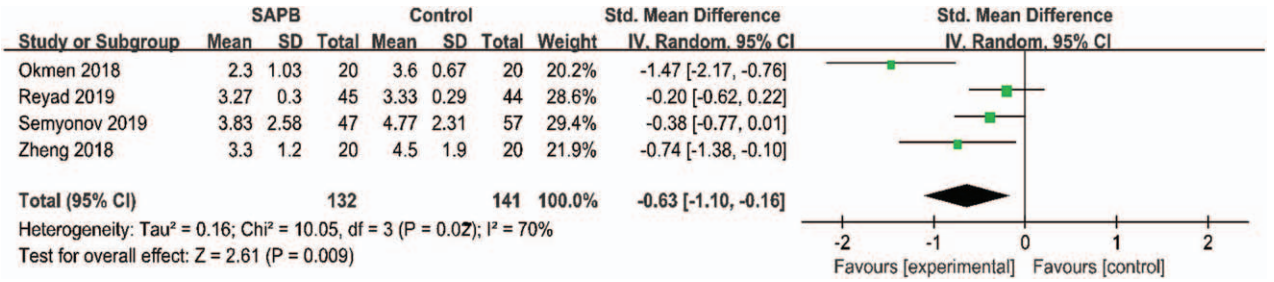

Figure 6. Forest plot for the meta-analysis of postoperative pain scores at 12 h.

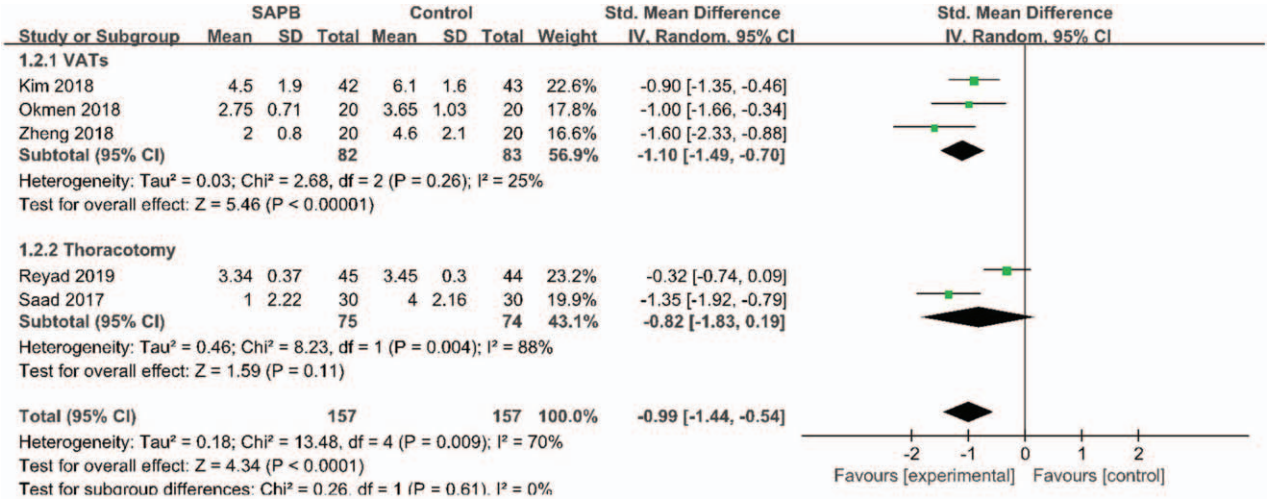

Figure 7. Forest plot for the meta-analysis of postoperative pain scores at 24 h.

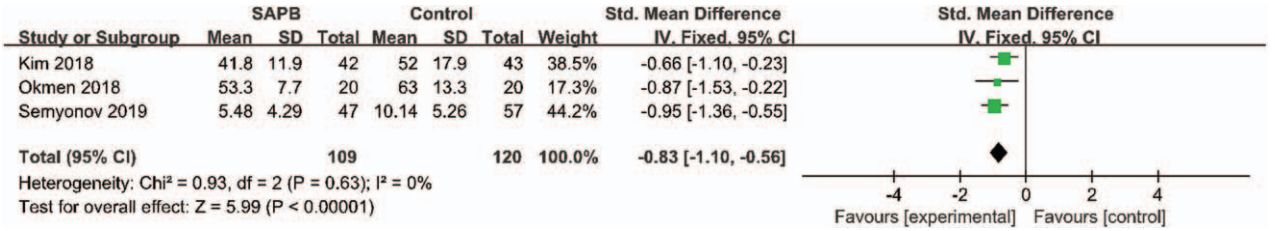

Figure 8. Forest plot for the meta-analysis of postoperative opioids consumption at 24 h.

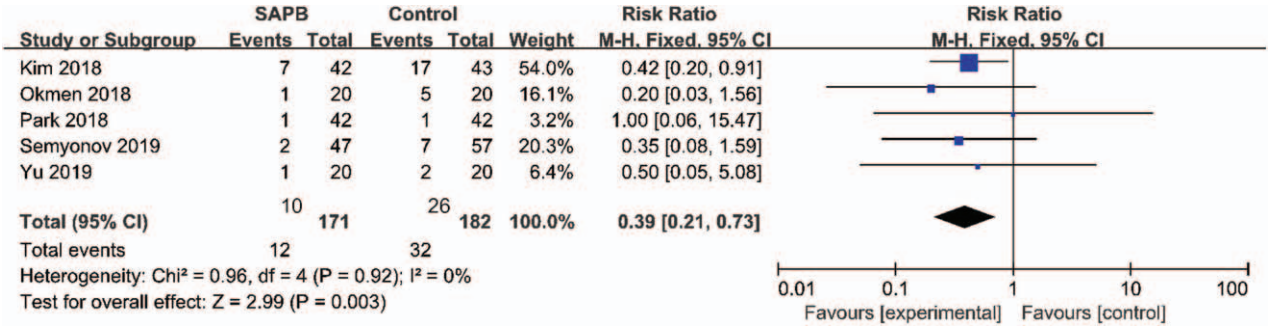

Figure 9. Forest plot for the meta-analysis of PONV.

strengthen statistical power and enlarger sample size by pooling results of published literature, which can provide stronger evidence.

Our meta-analysis indicate that the SAP block can play an important role in the management of pain at 2, 6, 12, and 24 h after thoracic surgery by reducing both pain scores and 24-h opioids consumption. In addition, there is fewer incidence of PONV in the SAP block groups. For our further subgroup analysis, the SAP block also significantly reduces pain scores postoperatively at different times in VATS group but not in thoracotomy group. The possible reason is that a SAP block is not believed to cover visceral pain and intense pain in thoracotomy, which may impact analgesic efficacy. Moreover, inter-individual differences in effectiveness can also be expected given that the degree of diffusion, and the mass of local anaesthetic reaching target nerves, is affected by factors such as site and volume of injection. Finally, the number of studies is small. So, more studies are required to demonstrate.

Although the present meta-analysis demonstrated that the new regional plane block could be used in pain relief after thoracic surgery, a single mode of pain management could not achieve adequate postoperative analgesia. SAP block could only act as a key of multimode analgesia and reduced postoperative complications and the use of opioids after operation.

Regarding the sensitivity analysis, there was still significant heterogeneity when performing the analysis by via omitting one study in turn or subgroup analysis. The main reasons for heterogeneity included:

1. The anesthesic drugs and concentrations used in RCT group were different. The drugs used in the 3 RCTs are bupivacaine, the concentrations of which were 0.25% and 0.5%, respectively. The concentrations of ropivacaine used in the other 4 RCTs were 0.5% and 0.375%, respectively. And one RCT, the drug was levobupivacaine at a concentration of 0.25%.
2. The detail methods and procedures of thoracic surgery were different, including VATS and thoracotomy.

The results of our meta-analysis have many limitations. First, a few centers seem to have started using SAP block for thoracic surgery. We could find 8 were RCTs. But more RCTs will be required for more stronger evidence in favor of SAP block in thoracic surgery. Secondly, because of limited outcomes of included studies, the effect of SAP block on the postoperative recovery of patients undergoing thoracic surgery still need to be further determined. Finally, the concentrations, type of anesthetic drugs in included RCTs were different, which may have an impact on the pooling results.

5. Conclusion

The SAP block can provide effective anaesthesia for thoracic surgery and reduce postoperative opioids consumption. In addition, the SAP block will decrease the side effects of PONV. However, further studies are required to demonstrate these benefits and higher quality RCTs are still required for further research.

Author contributions

Conceptualization: Jingjing Zhang.
Formal analysis: Xiancun Liu, Haiyang Xu.
Software: Xuejiao Chen.
Writing – original draft: Xiancun Liu, Tingting Song.
Writing – review: Pengfei Yin.

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