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Published online 2022 September 20 **Review Article**

A Meta-Analysis of the Effect of Serratus Anterior Plane Block after Thoracic Surgery

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Abstract

Background: As one of the new regional nerve block techniques, the serratus anterior plane block (SAPB) has demonstrated high potential in thoracic surgery.

Objectives: The present study aimed to analyze the effect of SAPB following thoracic surgery.

Methods: Chinese and English databases were retrieved to collect clinical randomized controlled studies (RCTs) on SAPB for postoperative analgesia in thoracic surgery. Both study and control groups were operated under general anesthesia, the SAPB was performed in the study group, and the rest of the postoperative analgesic regimen was the same as that of the control group. The following indicators were evaluated: (1) resting visual analogue scale (VAS) score (4, 12, and 24 h after the surgery), (2) active VAS score (4, 12, and 24 h after the surgery), (3) postoperative nausea and vomiting (PONV), (4) Postoperative Ramsay score (4-6 hours after operation), (5) Number of patient-controlled intravenous analgesia (PCIA) compressions, and (6) Postoperative sufentanil consumption. Stata software (version 15) was used for meta-analysis.

Results: The resting and active VAS scores at 4, 12, and 24 h postoperatively were lower in the study group than in the control group ($P< 0.05$), and there was no significant difference between the two groups in Ramsay scores at 4-6 h postoperatively ($P >0.05$). The incidence of PONV was significantly lower in the study group than in the control group ($P< 0.05$), and the number of postoperative PCIA compressions and sufentanil consumption were significantly less in the study group than in the control group ($P< 0.05$).

Conclusion: As evidenced by the obtained results, the SAPB can enhance the postoperative analgesic effect in thoracic surgery, reduce the incidence of PONV, and decrease opioid consumption.

Keywords: Meta-analysis, Postoperative analgesia, Postoperative nausea and vomiting, Serratus anterior plane block, Thoracic surgery

1. Background

Safe and effective pain management, which is the highlight of postoperative rehabilitation, can not only minimizes pain level but also reduces postoperative complications, shortens the time to out-of-bed activities, accelerates functional rehabilitation, reduces hospitalization costs, and improves patient satisfaction (1). The types of diseases in thoracic surgery primarily include esophageal cancer, lung cancer, cardiac disease, and breast cancer. The surgery is extensive and traumatic, with severe postoperative pain. Despite the application and promotion of minimally invasive techniques, such as video-assisted thoracoscopic surgery (VATS), in recent years, nearly 80% of patients still have moderate to severe postoperative pain, more than 50% of which can persist until one month after discharge (2).

Oral or intravenous administration of opioids is the main method of pain control after thoracic surgery, and most patients can achieve satisfactory analgesia. Nevertheless, high doses of opioids can lead to various adverse reactions, including postoperative nausea and vomiting (PONV), respiratory depression, and the slow recovery of intestinal function, which can affect postoperative recovery (3). Regional nerve blocks provide a new direction for postoperative analgesia. With the advancement of ultrasound visualization techniques, regional nerve block techniques have found a widespread application in postoperative pain management. One of the new regional nerve block techniques, the serratus anterior plane block (SAPB), has demonstrated high potential in thoracic surgery, with a longer duration of action and better safety compared to other methods, such as thoracic paravertebral nerve blocks (4,5).

2. Objectives

The present meta-analysis study aimed to assess the effect of SAPB for postoperative analgesia in thoracic surgery on the occurrence of PONV through, aiming to provide evidence to support its clinical application.

3. Methods

3.1. Literature inclusion criteria

(1) Clinical randomized controlled studies (RCTs) were included in this research. (2) Study population were patients aged ≥18 who underwent thoracic surgery under general anaesthesia. (3) Interventions:

SAPB was performed with local anaesthetics before or after the start of surgery in the study group (group S), with or without saline block in the control group (group C), and other postoperative analgesic regimens were the same in both groups, including patient-controlled intravenous analgesia (PCIA), oral analgesic medication, or intravenous analgesia. At least one of the following outcomes was described: (1) resting visual analogue scale (VAS) score (4 h, 12 h, and 24 h after surgery), (2) active VAS score (4 h, 12 h, and 24 h after surgery), (3) PONV Occurrence, (4) Ramsay score at 4-6 hours after operation, (5) Number of PCIA compressions, and (6) Postoperative sufentanil consumption (μg).

3.2. Literature exclusion criteria

(1) For duplicate reports involving the same study population, the literature with the largest sample size was included; (2) no study results were reported or the results did not meet the criteria; (3) animal experiments; (4) literature review studies, conference reports; (5) lower quality, or missing key data; (6) literature other than Chinese and English.

3.3. Literature search

A query was conducted on Chinese (CNKI, Wanfang Database, and CQVIP) and English electronic databases (PubMed, Web of Science, Embase, SinoMed, and Cochrane Library). The search time frame was from January 2015 to December 2021. Chinese keywords entailed thoracic surgery, serratus anterior plane block, pain, postoperative analgesia, postoperative nausea, and vomiting/PONV. MeSH-related terms were searched, and subject terms were retrieved with free words.

3.4. Literature Screening and Data Extraction

Literature screening was performed independently by two investigators, and data were extracted from the included literature and resolved by negotiation when disagreements arose. A data collection form was developed, and the extracted data included authors, year of publication of the literature, sample size, surgical procedure, anaesthesia protocol, postoperative analgesia protocol, and outcome indicators.

3.5. Literature quality evaluation

The modified Jadad scale, including random sequence generation, assignment anomalies, blinding, withdrawal, and dropout, was used for literature quality evaluation. The maximum score was 7 and the scores ≥4 were regarded as high-quality literature.

3.6. Statistical analysis

Stata software (version 15) was used for data analysis. For quantitative indicators (VAS score, Ramsay score, postoperative sufentanil consumption), weighted mean difference (WMD) was used as the effect size. On the other hand, for categorical indicators (chronic pain and PONV), odds ratio (OR) with 95% CI was used as the effect size. Cochrane Q test combined with I^2 values was used for literature heterogeneity. The outcome indicators with $P>0.1$ and $I^2<50\%$ were used for meta-analysis using the fixed-effects model, while outcome indicators with $P<0.1$ and $I^2>50\%$ were used for meta-analysis using the random-effects model. Publication bias was calculated using Egger's test, and the VAS score at rest was plotted against the incidence of PONV in a funnel plot.

4. Results

4.1. Literature search process and characteristics of included literature

A total of 23 eligible papers (17 Chinese and 6 English) were included in this study, and the PRISMA chart for presenting the flow of included papers is illustrated in Figure 1. There were 861 and 876 cases in the study and control groups, respectively. It is noteworthy that ropivacaine was used in 22 articles and bupivacaine was utilized in 1 paper, with Jadad score 4-7. The basic characteristics of the literature are displayed in Table 1 (6-28).

4.2. Meta-analysis results

4.2.1. Visual analogue scale scores at rest

A number of 10, 13, and 18 essays described pain VAS scores at rest at 4, 12, and 24 h postoperatively, respectively. Heterogeneity existed between studies for all of these indicators, and random-effects meta-analysis showed that the pain VAS scores at 4, 12, and 24 h postoperative rest were lower in the study group than in the control group, with a WMD of -1.38 (95% CI: -1.75, -1.01), -0.86 (95% CI: -1.21, -0.52), and -0.52 (95% CI: -0.75, -0.30), respectively (Figure 2-4).

4.2.2. Active visual analogue scale scores

Five essays described pain VAS scores during activity at 4 h and 12 h postoperatively, and eight essays described pain VAS scores during activity at 24 h postoperatively. There was heterogeneity among the studies for all of these indicators. The results of the random-effects meta-analysis indicated that the pain VAS scores at 4, 12, and 24 h postoperatively were lower in the study group than in the control group, with a WMD of -1.62 (95% CI: -1.95, -1.29), -1.07 (95% CI: -1.46, -0.67) and -0.67 (95% CI: -1.11, -0.24) (Figure 5-7).

4.2.3. Postoperative nausea and vomiting

Fifteen essays described the incidence of PONV, pointing to heterogeneity among studies. The results of the random-effects meta-analysis illustrated that the incidence of PONV was significantly lower in the study group than in the control group (OR=0.50, 95% CI: 0.27, 0.90) (Figure 8).

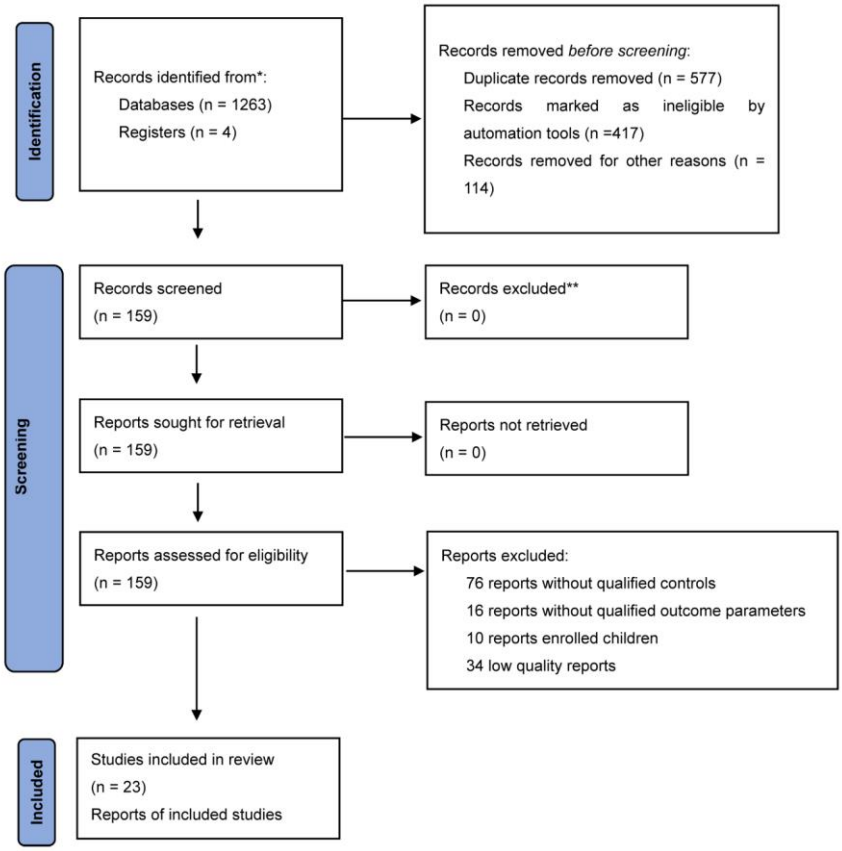

Figure 1. PRISMA chart for presenting the flow of the included papers
A total of 23 eligible papers were included in this study

Table 1. Basic characteristics of the included studies

Author	Year	Surgical protocol	Sample size	SAPB block		Outcome	Jadad score
			(S/C)	Group S	Group C		
R Shi (6)	2020	Thoracoscopic surgery	80/79	0.5% Ropivacaine 20ml	No block	③	4
C Han (7)	2016	Radical Breast Cancer Surgery	20/20	0.375% Ropivacaine 20ml	Physiological saline	④	5
H Huang (8)	2019	Thoracoscopic surgery	19/20	0.33% Ropivacaine 30ml	No block	③⑤	6
LH Shang (9)	2018	Thoracoscopic surgery	30/30	0.5% Ropivacaine 20ml	Physiological saline	①③	6
HR Yu (10)	2019	Thoracoscopic radical surgery for non-small cell lung cancer	20/20	0.375% Ropivacaine 20ml	Physiological saline	①②⑤	6
J Meng (11)	2018	Thoracoscopic radical lung cancer resection	30/30	0.375% Ropivacaine 20ml	Physiological saline	①②③	4
LS Zhang (12)	2019	Radical Breast Cancer Surgery	30/30	0.3% Ropivacaine 25ml	No block	①⑤⑥	5
Y Zong (13)	2019	thoracoscopic lobectomy	28/28	0.375% ropivacaine 0.4 ml/kg	No block	①③④	4
LS Zhang (14)	2018	Thoraco-laparoscopic radical esophageal cancer surgery	30/30	0.4% Ropivacaine 20ml	Physiological saline	①②⑤⑥	6
Y Dong (15)	2019	Breast prosthesis implantation	25/25	0.375% Ropivacaine 20ml	Physiological saline	①③④⑥	6
HJ Wang (16)	2021	Thoracoscopic surgery	52/52	0.4% Ropivacaine 30ml	No block	①②③	5
HX Jin (17)	2021	open heart surgery	108/108	0.4% Ropivacaine 20ml	Physiological saline	①②③⑥	6

Table 1. Continued

RF Wang (18)	2021	Ventricular septal defect surgery	34/46	0.5% Ropivacaine 20ml	No block	⑥	5
M Xia (19)	2020	Thoracoscopic lobectomy	30/30	0.375% Ropivacaine 20ml	No block	①②⑤	5
LF Li (20)	2021	Radical Breast Cancer Surgery	35/35	0.375% Ropivacaine 20ml	Physiological saline	①②③④	5
L Ma (21)	2020	Modified radical mastectomy for breast cancer	30/30	3.75g/L ropivacaine 25ml	No block	①③	4
HB Yang (22)	2019	Single-port thoracoscopic radical lung cancer resection	30/30	0.375% Ropivacaine 30ml	Physiological saline	③④	5
MH Park (23)	2018	Thoracoscopic surgery	42/42	0.375% Ropivacaine 30ml	Physiological saline	①	6
M Semyonov (24)	2019	Thoracic Surgery	47/57	0.25% bupivacaine 2mg/kg	No block	①	6
FW Abdallah (25)	2021	Breast cancer surgery	20/20	0.5% Ropivacaine 20ml	Physiological saline	①③	7
YK Xiao (26)	2021	Radical Breast Cancer Surgery	28/28	0.33% Ropivacaine 30ml	No block	①③	6
W Gao (27)	2021	Video-assisted thoracoscopic surgery	60/60	0.375% Ropivacaine 40ml	No block	①②③	6
A Toscano (28)	2020	Mitral valve surgery	33/26	0.375% Ropivacaine 20ml	Physiological saline	①	7

Outcomes definition: ① resting visual analogue scale score (4, 12, and 24 h after surgery), ② active VAS score (4, 12, and 24 h after surgery, ③ Postoperative nausea and vomiting occurrence,④ Ramsay score at 4-6 hours after the operation, ⑤ Number of patient-controlled intravenous analgesia (PCIA) compressions, and ⑥ Postoperative sufentanil consumption (μg), Serratus anterior plane block (SAPB)

4.2.4. Postoperative Ramsay scores

Five essays described Ramsay scores at 4-6 h postoperatively, signifying heterogeneity among studies. The results of the random-effects meta-analysis displayed no significant difference in Ramsay scores between the study group and the control group at 4-6 h postoperatively (P> 0.05) (Figure 9).

4.2.5. Number of postoperative patient-controlled intravenous analgesia compressions and sufentanil consumptions

Five papers described the number of postoperative PCIA compressions, and five papers described the amount of postoperative sufentanil consumption, and heterogeneity existed between studies for all of these indicators. A random-effects model meta-analysis showed that the number of postoperative PCIA compressions was lower in the study group than in the control group (WMD=-5.39, 95% CI: -7.98, -2.80) and less postoperative sufentanil consumption in the study group than in the control group (WMD=-22.73 μg, 95% CI: -41.14, -4.32) (Figure 10 and 11).

4.3. Sensitivity analysis

To verify the stability of the results, VAS, PONV,

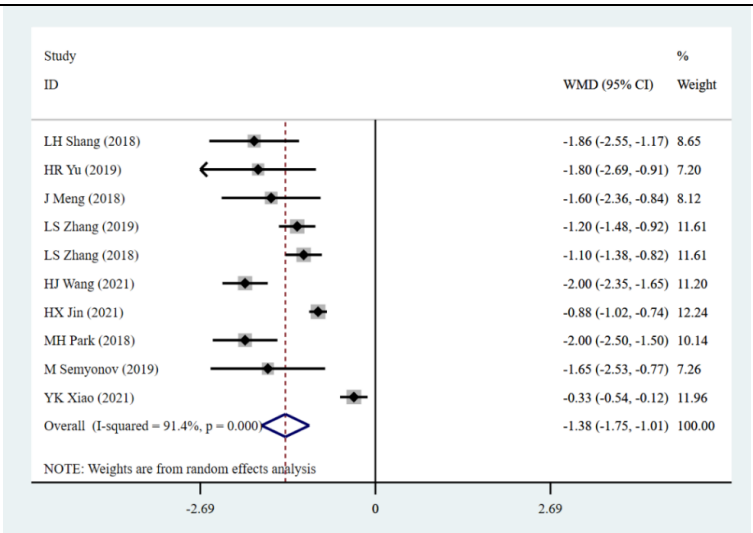

Figure 2. Visual Analogue Scale (VAS) scores at rest at 4 h postoperatively. Ten assays described pain VAS scores at rest at 4 h postoperatively. The pain VAS scores at 4 h postoperative rest were lower in the study group than in the control group, with a WMD of -1.38 (95% CI: -1.75, -1.01)

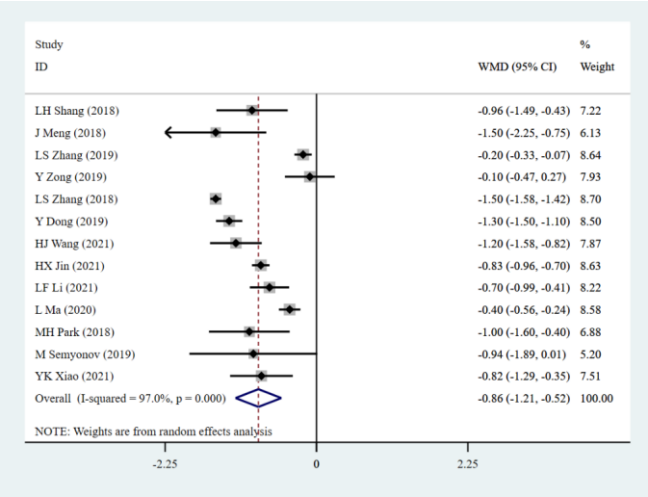

Figure 3. Visual Analogue Scale (VAS) scores at rest at 12 h postoperatively. A number of 13 essays described pain VAS scores at rest at 12 h postoperatively. The pain VAS scores at 12 h postoperative rest were lower in the study group than in the control group, with a WMD of -0.86 (95% CI: -1.21, -0.52)

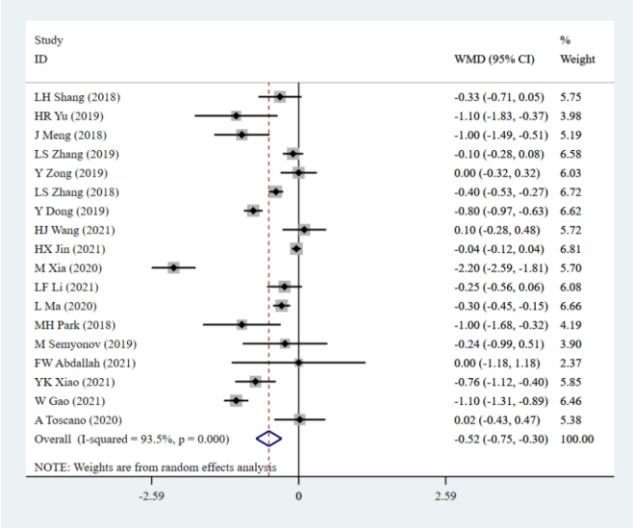

Figure 4. Visual Analogue Scale (VAS) scores at rest at 24 h postoperatively. A total of 18 essays described pain VAS scores at rest at 24 h postoperatively. The pain VAS scores at 24 h postoperative rest were lower in the study group than in the control group, with a WMD of -0.52 (95% CI:-0.75, -0.30)

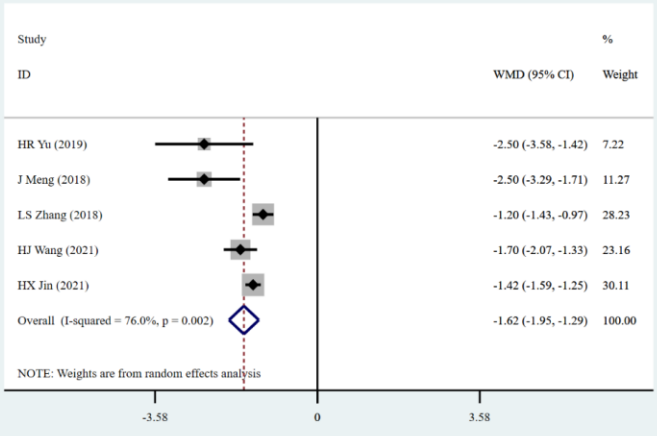

Figure 5. Active Visual Analogue Scale (VAS) score at 4 h postoperatively. Five essays described pain VAS scores during activity at 4 h postoperatively. The pain VAS scores at 4 h postoperatively were lower in the study group than in the control group, with a WMD of -1.62 (95% CI: -1.95, -1.29).

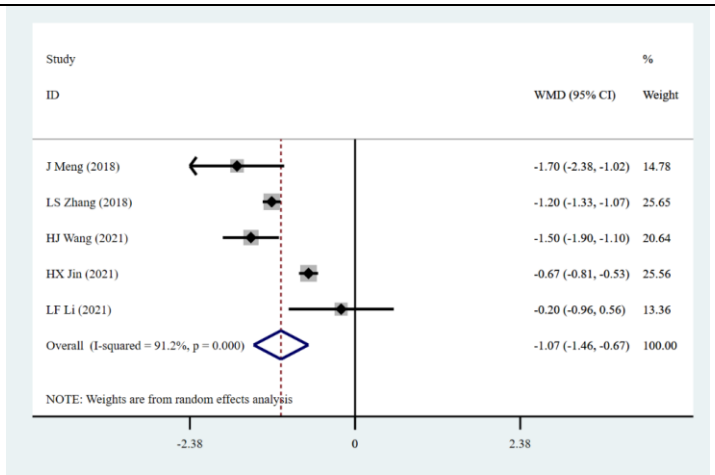

Figure 6. Active Visual Analogue Scale (VAS) score at 12 h postoperatively. Five essays described pain VAS scores during activity at 12 h postoperatively. The pain VAS scores at 12 h postoperatively were lower in the study group than in the control group, with a WMD of -1.07 (95% CI: -1.46, -0.67)

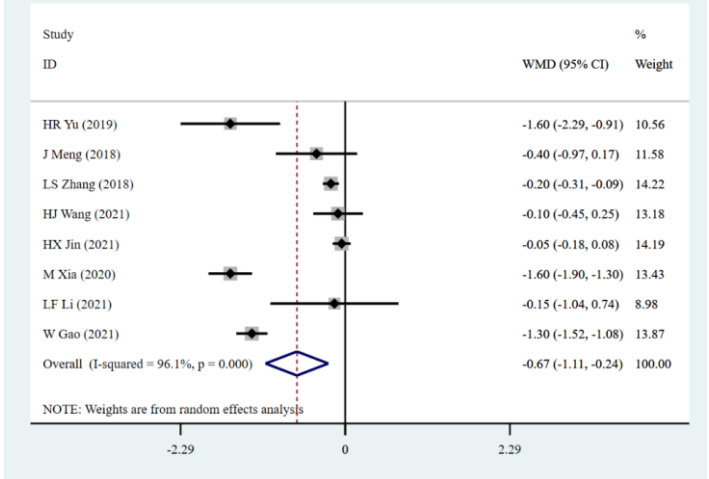

Figure 7. Active Visual Analogue Scale (VAS) score at 24 h postoperatively. Eight essays described pain VAS scores during activity at 24 h postoperatively. The pain VAS scores at 24 h postoperatively were lower in the study group than in the control group, with a WMD of -0.67 (95% CI: -1.11, -0.24)

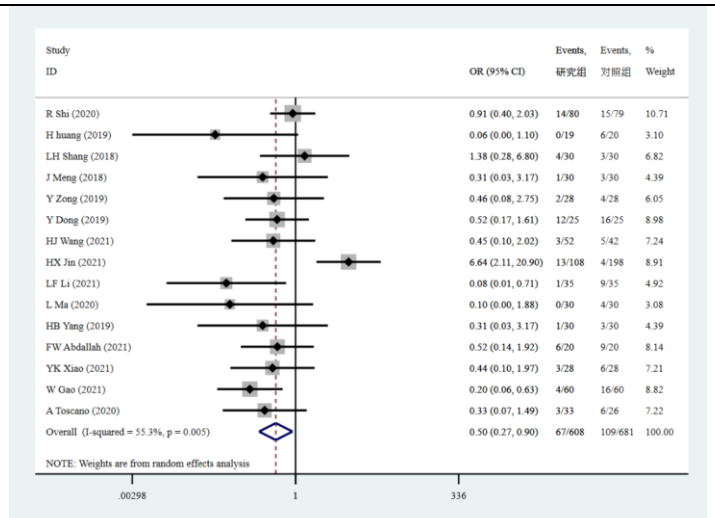

Figure 8. Occurrence of postoperative nausea and vomiting (PONV). A total of 15 essays described the incidence of PONV. The incidence of PONV was significantly lower in the study group than in the control group (OR=0.50, 95% CI: 0.27, 0.90)

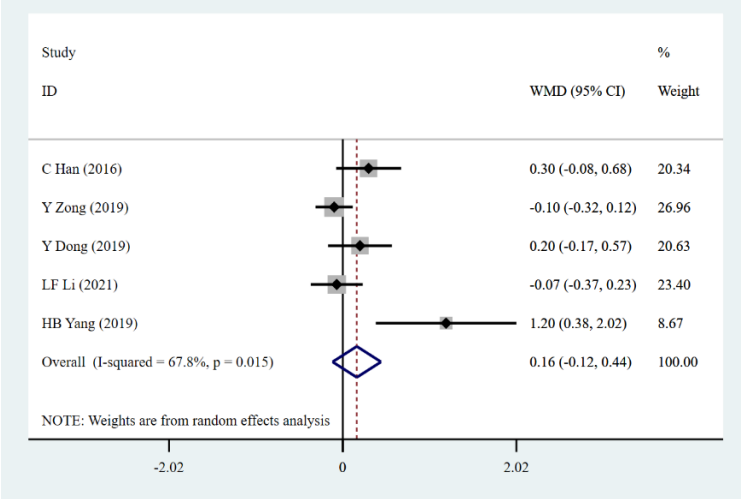

Figure 9. Ramsay score at 4~6 h postoperatively. Five essays described Ramsay scores at 4-6 h postoperatively. There was no significant difference between the study and control groups in Ramsay scores at 4-6 h postoperatively (P> 0.05).

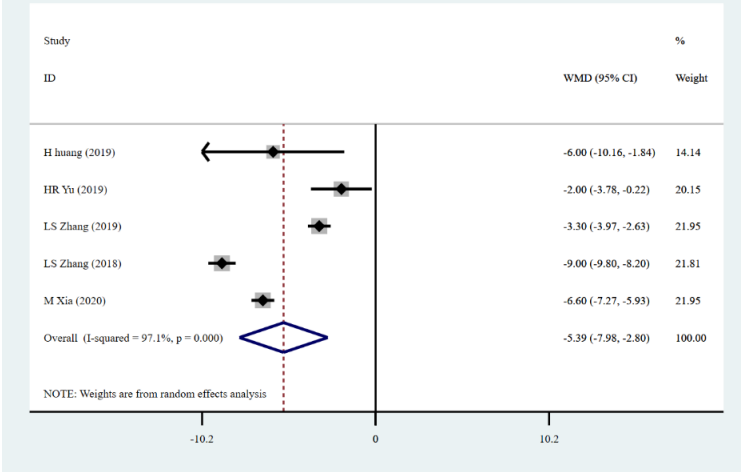

Figure 10. Number of postoperative patient-controlled intravenous analgesia (PCIA) compressions. Five papers described the number of postoperative PCIA compressions. The number of postoperative PCIA compressions was lower in the study group than in the control group (WMD = -5.39, 95% CI: -7.98, -2.80)

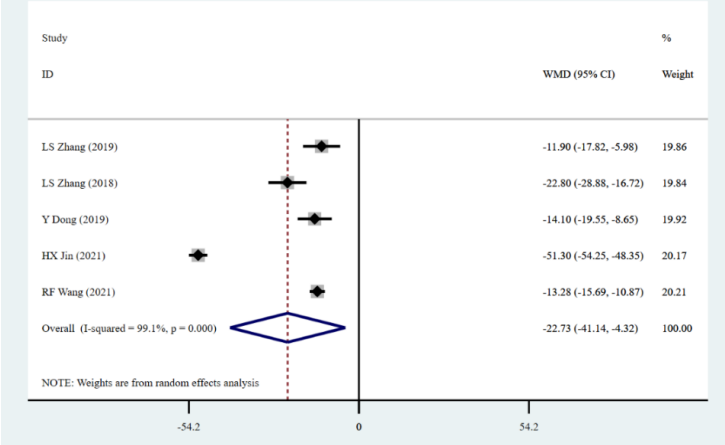

Figure 11. Postoperative sufentanil consumption (μg). Five papers described the amount of postoperative sufentanil consumption. The amount of postoperative sufentanil consumption was less in the study group than in the control group (WMD=-22.73 μg, 95% CI: -41.14, -4.32)

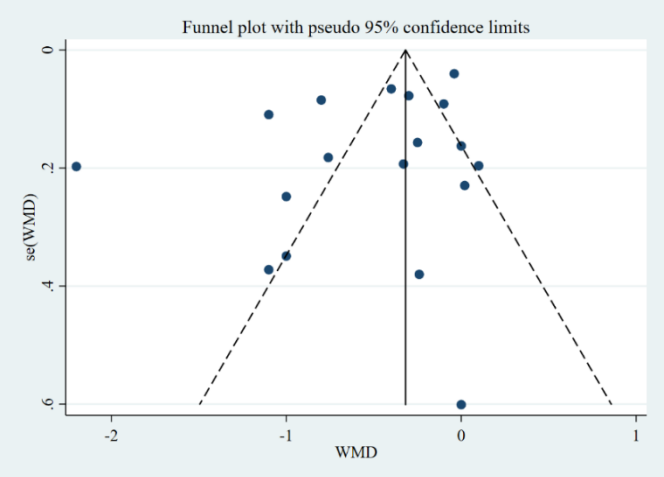

Figure 12. Postoperative 24 h resting Visual Analogue Scale (VAS) score funnel plot. The distribution of resting VAS score funnel plot at 24 h postoperatively was more symmetrical

Ramsay score, Number of PCIA compressions and sufentanil consumption were analyzed again after the exclusion of each included literature one by one, and the results revealed that none of the findings altered significantly.

4.4. Publication bias

The publication bias of the main indicators was analyzed by funnel plot with Egger's test, the funnel plot of resting VAS scores at 24 h postoperatively is illustrated in Figure 12, and the funnel plot of PONV incidence is displayed in Figure 13. It can be observed that the distribution of the resting VAS score funnel plot at 24 h postoperatively was more symmetrical. Based on Egger's test, there was no publication bias (P>0.05), the distribution of PONV incidence funnel plot was less symmetrical, and Egger's test showed that there was publication bias (P<0.05).

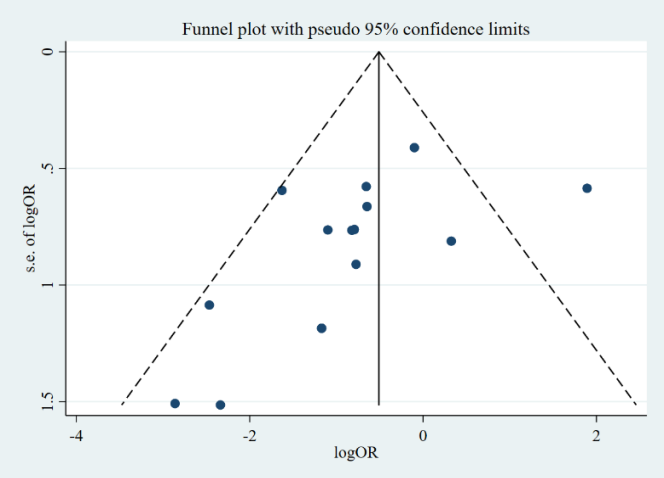

Figure 13. Postoperative nausea and vomiting (PONV) incidence funnel plot. The distribution of the PONV incidence funnel plot was less symmetrical

5. Discussion

As evidenced by the results of this study, Anterior serratus plane block enhances postoperative analgesia and reduces analgesic drug consumption in thoracic surgery. An ideal analgesic method needs to have a high success rate, good analgesic satisfaction, high controllability, and few complications. Intravenous administration of opioids is currently the primary protocol for postoperative analgesia in thoracic surgery. Due to individual differences and other reasons, some patients require larger doses to achieve satisfactory analgesia, leading to a high incidence of adverse reactions and affecting postoperative recovery (29).

Regional nerve blocks combined with opioids provide an ideal solution to these problems, and intercostal nerve blocks, thoracic paravertebral blocks, and thoracic epidural blocks are commonly performed. Among them, the epidural block is effective; nonetheless, it has complicated procedures, exerts a negative impact on circulation and respiration, and cannot be used in patients with abnormal coagulation and long-term administration of

anticoagulant drugs. Thoracic paravertebral block can achieve analgesic effects similar to those of epidural block; however, it has less impact on circulation and respiration, has a significantly better safety profile, and is the gold standard method of regional nerve block in postoperative thoracic surgery (30). Nevertheless, the failure rate of thoracic paravertebral blocks is high and is not conducive to catheter retention for continuous postoperative analgesia.

The intercostal nerve block requires the injection of local anaesthetic drugs in multiple segments during the procedure, with high consumption of drugs close to the pleura and intercostal vessels, easily leading to multiple adverse reactions. Therefore, the aforementioned regional block methods still cannot achieve satisfactory outcomes and safety in postoperative analgesia in thoracic surgery. The SAPB is a new type of regional block technique proposed by British scholar Blanco et al. (31). It superficially injects bupivacaine into the fourth intercostal serratus anterior in the midaxillary line under the guidance of ultrasound. After 30 min, it was found that the block plane covered the anterior chest wall, the lateral chest wall, and the posterior chest wall, ranging from T2-T9.

The follow-up study mostly used ropivacaine, and the effect was similar. A study by Chu et al. (5) pointed out that SAPB can provide satisfactory postoperative analgesia for patients after thoracoscopy, and its analgesic effect is more durable than that of the thoracic paravertebral block with fewer complications and simpler procedures, reducing the need for postoperative pharmacological analgesia. The present study demonstrated that SAPB could effectively improve postoperative pain management in thoracic surgery. On the basis of the conventional analgesic regimen, patients who were given SAPB before the beginning or at the end of surgery had significantly lower pain scores at rest and during activity within the 24 h after surgery and less acute severe pain. Moreover, their postoperative Ramsay scores did not significantly improve or decrease, and the SAPB effectively reduced the consumption of postoperative opioids and opioid-related side effects while improving analgesic effects and provide a foundation for early recovery.

The SAPB reduces the incidence of PONV which is a common postoperative complication following general anesthesia (32). The PONV can reduce patient comfort, affect postoperative rehabilitation, and can lead to serious complications, such as aspiration pneumonia, asphyxia, water-electrolyte disorders and dehydration in severe patients, reduced surgical and anaesthetic safety, increased burden on medical and nursing staff, as well as patients' economic burden (33). It can also lead to or aggravate postoperative anxiety, enhance psychological stress, affect hemodynamic stability, and reduce patient' pain threshold (34). Therefore, the prevention and treatment of PONV are of great importance in the promotion of postoperative rehabilitation. The present study pointed out that the incidence of PONV was significantly lower in the study group treated by SAPB. The SAPB had positive significance for the prevention and treatment of PONV, confirming its usefulness in postoperative analgesia in thoracic surgery and facilitated postoperative rehabilitation. The mechanism of SAPB to reduce PONV may be ascribed to the reduction of opioid consumption; nonetheless, it needs to be verified in further research.

6. Conclusion

In conclusion, SAPB can improve the effect of postoperative analgesia in thoracic surgery, reduce the consumption of postoperative opioids, and reduce the incidence of PONV. Among the notable limitations of the current study, we can refer to the mere inclusion of Chinese and English articles, affecting the quality of evidence and the generalization of the results, publication bias, and the low overall quality of the included literature studies. It is suggested that researchers further explore the effectiveness and safety of SAPB in thoracic surgery, as well as the impact of different SAPB methods on the treatment effectiveness and safety, through high-quality clinical studies.

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Footnotes

Conflicts of Interest: The authors declared no conflict of interest.
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