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ORIGINAL ARTICLE

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Serratus anterior plane block for cardiothoracic surgeries: a meta-analysis of randomized trials

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Abstract

Background: Comparison of serratus anterior plane block to different analgesic methods for anterolateral thoracic wall incisions. Meta-analysis was used to address this concern. Authors systemically searched the MEDLINE, EMBASE, PubMed, and Cochrane databases to identify all published randomized and prospective clinical trials, comparing the SAPB with other methods that used for analgesia in different thoracic surgical procedures and trauma.

Results: Ten studies were identified for inclusion in this study, involving a total of 735 patients. Meta-analysis showed that, compared with thoracic wall analgesia and PCA methods, the SAPB group resulted in a significant decrease in pain scores, significant decrease in consumption of analgesic drugs, and a significant decrease in the incidence of nausea and vomiting with no difference in the rate of hypotension.

Conclusions: The use of SAPB in cardiothoracic surgery and trauma is a safe and effective option for thoracic analgesia.

Keywords: Serratus anterior plane block, Postoperative pain, Cardiothoracic surgeries

Background

Acute postoperative pain leads to delayed postoperative discharge, increases risk of ileus, impairs pulmonary and immune functions, thromboembolism, myocardial infarction, and may lead to increased length of hospital stay. It is also an essential factor leading to the development of chronic persistent postoperative pain (Garg et al., 2018).

Hence, effective perioperative pain management of patients undergoing thoracic surgery is mandatory. Regional nerve blocks have been considered as one of the modalities for effective perioperative analgesia. They have an opioid-sparing impact and allow early mobilization and early discharge from the hospital. With the advent of ultrasound (U.S.), newer interventions such as fascial plane blocks have been reported for perioperative analgesia in thoracic surgeries (Piccioni et al., 2018).

Before ultrasound-guided regional anesthesia, the range of thoracic wall blocks was mainly confined to three techniques: thoracic epidural analgesia (TEA), thoracic para-vertebral blockade (TPVB), and intercostal nerve blocks (Abd El-Hamid & Azab, 2016). Ultrasound revolutionized regional anesthesia by allowing real-time visualization of anatomical structures, needle advancement, and L.A. spread (Chin, 2019).

The use of the U.S. led to the refinement of existing techniques and the introduction of new ones. Ultrasound has been critical in the development of fascial plane blocks, in which a L.A. is injected directly into a tissue plane rather than directly around nerves. These blocks are believed to work by the passive spread of L.A. to nerves travelling within that tissue plane or adjacent

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Table 1 Characteristics of included studies

Study ID	Type of surgery	Study design	No. of participants	Patients characteristics	Outcomes	Level of evidence
Khalil et al., 2017	Thoracotomy	A prospective randomized observer-blinded controlled study–single-center study	Group SAPB (*n* = 20) Group TEA (*n* = 20)	Twenty to 60 years old with ASA class II and III	VAS pain score Morphine consumption MAP & H.R.	L2
Ökmen & Ökmen, 2018	Video-assisted thoracoscopic surgery	A randomized, controlled, single-blind study	Group T (IV PCA tramadol (*n* = 20) Group S (IV PCA tramadol + SAPB (*n* = 20).	18 to 70 years old with ASA class I–III	Visual analogue scale (VAS) The quantity of tramadol Side effect additional analgesic use.	L2
Park et al., 2018	Thoracoscopic surgery	A randomized, controlled blind study	Eighty-nine patients to block with 30 ml ropivacaine 0.375% (*n* = 44), or no block without placebo or sham procedure (*n* = 45).	ASA physical status I or II patients aged 20–80 years, scheduled for thoracoscopic segmentectomy or lobectomy.	Fentanyl consumption. Numeric pain rating scale (NRS) score (0–10) Nausea, vomiting, dizziness, pruritus and respiratory rates Participants satisfaction Hospital stay	L2
Kaushal et al., 2019	Pediatric cardiac surgery	A prospective, randomized, single-blind, comparative study–single-center study	Group SAPB (*n* = 36) Group Pecs II (*n* = 36) Group ICNB (*n* = 36)	One hundred eight children with congenital heart disease requiring surgery through a thoracotomy.	Modified objective pain score (MOPS). Analgesia consumption Extubation time Adverse effects	L2
Saad et al., 2018	Lung lobectomy	Randomized, controlled study–single center study	Group TPVB (*n* = 30) Group SAPB (*n* = 30) Group Control (*n* = 30)	Ninety patients with lung cancer scheduled for lung lobectomy	Visual analogue scale (VAS) Analgesic consumption Time of first rescue analgesic Adverse effects.	L2
Kim et al., 2018	Video-assisted thoracic surgery	A randomized, triple-blind, placebo-controlled study–single center study	SAPB group (*n* = 42) Control group (*n* = 43)	Patients with 20–65 years old and ASA class of I or II, who were scheduled for elective VATS	Quality of recovery (QoR-40) score Pain scores Opioid consumption Adverse events	L2
Semyonov et al., 2019	Thoracic surgery	Prospective, randomized, controlled, double-blind and single-center study	Group 1: Control group (*n* = 57) Group 2: SAPB group (*n* = 47)	One hundred four patients who underwent elective thoracotomy	Duration of PACU stay Duration of hospital stay VAS PONV scores, complications Hemodynamic variables	L2
Lee & Kim, 2019	Video-assisted thoracoscopic lobectomy	Randomized, controlled, blinded study–single center study	Group G (*n* = 25) received conventional G.A. Group S (*n* = 25) received SAPB	Fifty participants, aged 20 to 75 years, undergoing VATS lobectomy	Intraoperative remifentanil consumption. Emergence time, systolic blood pressure (SBP) Hemodynamic variables Doses of rescue drugs used to control BP	L2
Reyad et al., 2019	Thoracotomies	Randomized controlled trial–single center study	Group A: PCA–group (*n* = 44) Group B: SAPB group (*n* = 45)	Eighty-nine patients with chest malignancies, scheduled for thoracotomy	Assessment for the emergence of PTPS at 12 weeks VAS score Quality of life	L2
Hanley	Videoscopic	A single-centre, double-	Group SAPB (*n* = 20)	Forty patients undergoing VATS	Opioid	L2

Table 1 Characteristics of included studies *(Continued)*

Study ID	Type of surgery	Study design	No. of participants	Patients characteristics	Outcomes	Level of evidence
et al., 2020	assisted thoracic surgery (VATS).	blinded, randomized, non-inferiority study–single center study	Group SPVB (*n* = 20)		consumption Numerical rating scores Hemodynamic variables Side-effects Length of hospital stay Patient satisfaction	

tissue compartments containing nerves (van Geffen & Bruhn, 2017).

The SAPB, Pecs I, and Pecs II were first introduced as safer alternatives to TPVB for breast surgery. It is important to note that the Pecs I and SAP blocks are distinct techniques that target two different fascial planes. In contrast, the Pecs II involves the injection into both of these fascial planes and is, therefore, a combination of both Pecs I block and SAPB block (Williams et al., 2019).

The objective of this meta-analysis is to evaluate the SAPB in the setting of analgesia for antero-lateral thoracic wall incisions of thoracic wall trauma and cardiothoracic surgeries, including open thoracotomy and video-assisted thoracoscope, in comparison to different analgesic modes including intravenous analgesia and different regional methods even as single-shot or continuous infusion of intravenous analgesia or local anesthetic drugs.

Methods

Search strategy and selection criteria

This meta-analysis was performed using MEDLINE, EMBASE, PubMed, and Cochrane to identify all

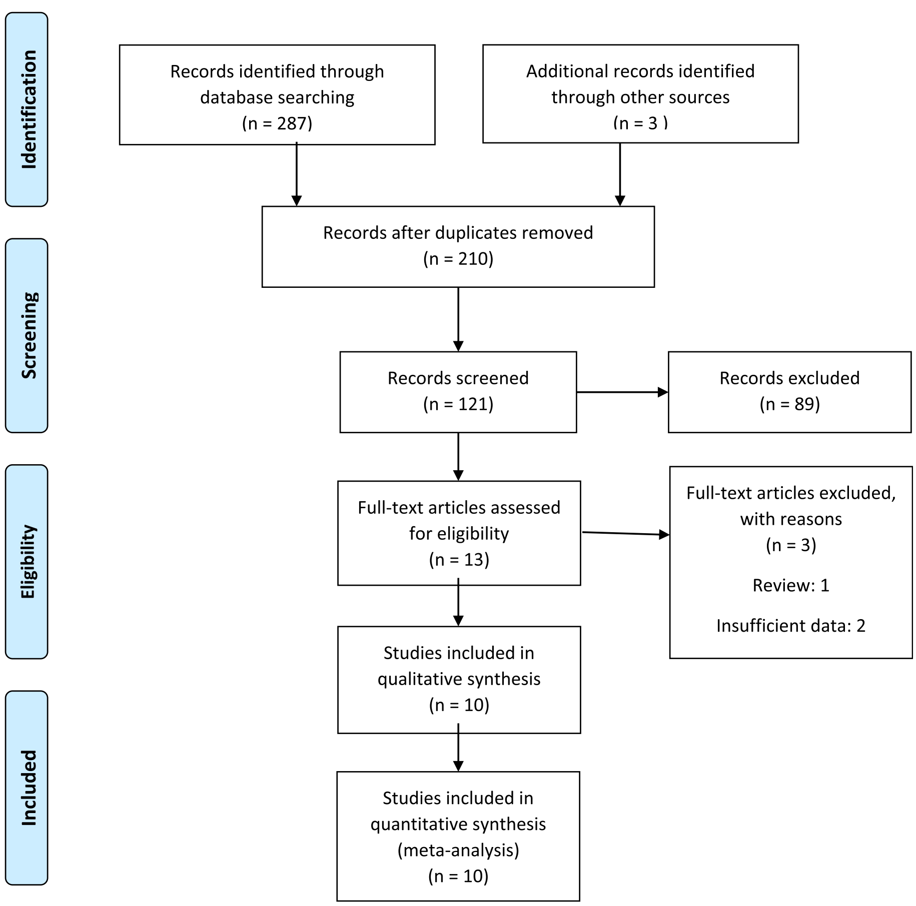

Fig. 1 The overall process of study selection and identification

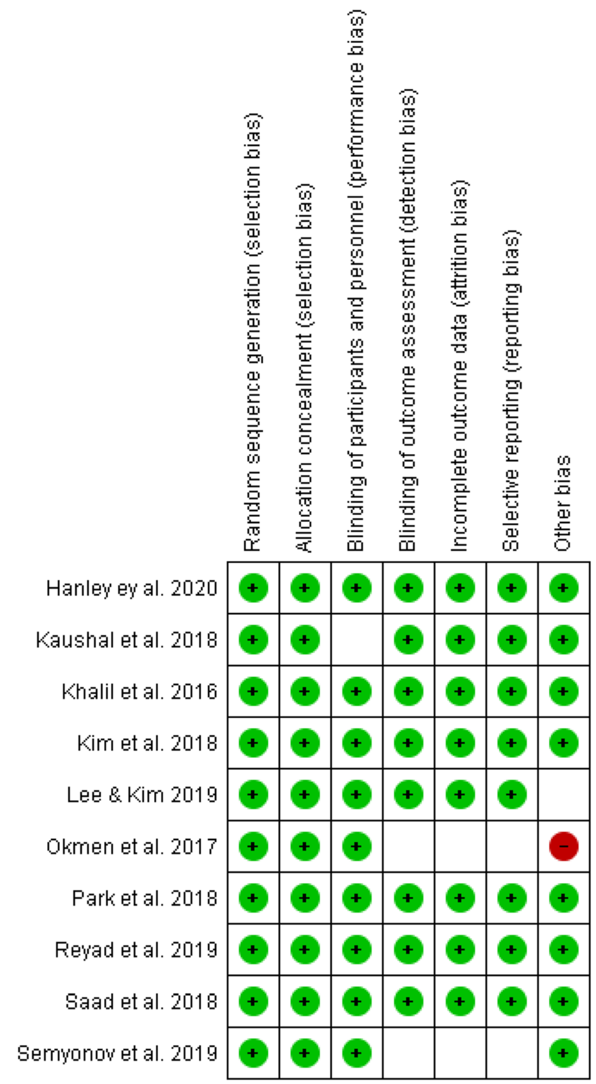

Fig. 2 Risk of bias summary

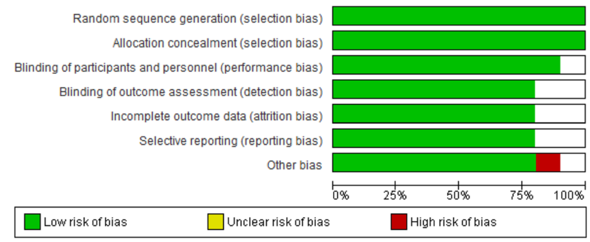

Fig. 3 Risk of bias graph

published randomized and prospective clinical trials, comparing the SAPB with other methods that used for analgesia in different thoracic surgical procedures. Relevant articles were distinguished using the following search terms: 'serratus blocks' and 'surgery of thoracic or thoraco'. Studies were limited to the human and English language with no date restrictions. The authors also reviewed reference lists of related articles. This article required no approval from the Institutional Review Board.

Exclusion criteria
Studies were excluded if their data were absent or deficient, or the study authors were inaccessible or did not reply if extra data from their trials were required.

Mechanism of serratus anterior plane (SAP) block
The basic SAP block involves LA injection into a fascial plane that may be either superficial to or deep into the serratus anterior muscle the fascial planes between serratus anterior muscle and pectoralis minor or latissimus dorsi muscles, or between serratus anterior muscle and intercostal muscles and ribs are the target area of the block. The boundaries of SAP block are the anterior axillary line and posterior axillary line, and the second to seventh ribs. The lateral cutaneous branches of intercostal nerves are the target nerves of SAP block, with the actual nerves involved being determined largely by the exact point of injection and the volume of injectate. However, the efficacy of the SAP block in thoracotomy and rib fractures suggests that it may also anesthetize deeper structures (Chin, 2019).

Data extraction
Data extraction was undertaken from included randomized trial on the first author, year of publication, study design, sample size, setting, and all outcomes of interest. The primary endpoints of this analysis were pain score at 6, 12, and 24 h. Secondary outcomes included analgesia consumption, the incidence of hypotension, and adverse effects (nausea and vomiting).

Quality assessment and risk of bias
Authors assessed the quality of trials using the risk of bias tool recommended by the Cochrane Collaboration (Higgins et al., 2019). We assigned a high, unclear, or low value to the following items: Random sequence generation, allocation concealment, blinding, incomplete outcome data, selective reporting, and other bias. Any disparities were identified and resolved through discussion.

Statistical analysis
We conducted this meta-analysis to pool the results of trials comparing SAPB only with other methods used for thoracic wall block and patient-controlled analgesia using Review Manager (RevMan), Version

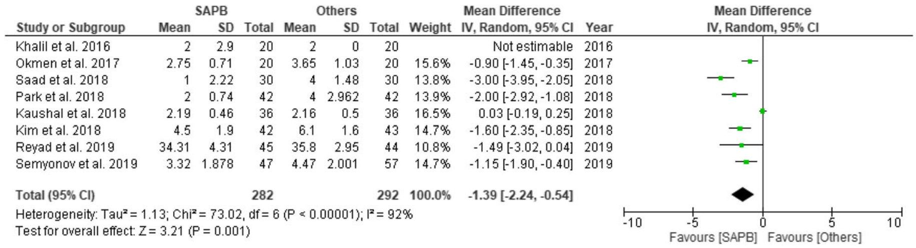

Fig. 4 Pain score at 6 h

5.3. Copenhagen (The Nordic Cochrane Centre, The Cochrane Collaboration, 2014). The primary outcome was pain score at 6, 12, and 24 h postoperative. Secondary outcomes included analgesia consumption, the incidence of hypotension and adverse effects. We considered that the mean and median were equal for studies reporting only the interquartile range (IQR) for continuous measure outcomes. We calculated the standard deviation (S.D.) from IQR by dividing the IQR by 1.35 (Wan et al., 2014). Heterogeneity was assessed using the I^2 statistic. We used random-effects models to pool results. We calculated risk ratios (R.R.s) for dichotomous outcomes. The mean difference (M.D.) was calculated for continuous outcomes, with their corresponding 95% confidence intervals (C.I.s). Statistical significance was defined using a two-sided α of 0.05, and interpretations of clinical significance emphasized C.I.s.

Results

Study selection

The search initially identified 287 articles through database searching and 3 articles through other sources; 210 articles remained after duplicates were removed. After articles screening, 89 articles were excluded, and 121 articles remain. After a full article assessment for eligibility, 13 studies remain. Then, by full-text assessment of the remaining articles, further 3 studies were excluded, as 1 study was a review, and 2 studies have insufficient data. We finally identified 10 eligible randomized trials (Fig. 1).

Characteristics and quality of clinical studies included in the meta-analysis

The studies included in the analysis are detailed in Table 1. Ten studies were identified for inclusion in this study, involving a total of 735 patients. Of which eight were RCTs (Khalil et al., 2017; Ökmen & Ökmen, 2018; Park et al., 2018; Saad et al., 2018; Kim et al., 2018; Semyonov et al., 2019; Lee & Kim, 2019; Reyad et al., 2019). Five trials evaluated the SAPB in the setting of thoracoscopic surgery (Ökmen & Ökmen, 2018; Park et al., 2018; Kim et al., 2018; Lee & Kim, 2019; Hanley et al., 2020), and four trial evaluated the SAPB in thoracotomy (Khalil et al., 2017; Saad et al., 2018; Semyonov et al., 2019; Reyad et al., 2019). One trial evaluated the SAPB in pediatric cardiac surgery (Kaushal et al., 2019). Five of these compared SAPB with IV analgesia alone (Ökmen & Ökmen, 2018; Kim et al., 2018; Semyonov et al., 2019; Lee & Kim, 2019; Reyad et al., 2019); two compared it with TPVB (Saad et al., 2018; Hanley et al., 2020); one compared it with PECS 2 blocks and with intercostal nerve blocks (Kaushal et al., 2019) and one compared it with surgically-placed continuous TPVB (Hanley et al., 2020). Only one study compared it with TEA (Khalil et al., 2017). The risk of bias in the 10 trials was generally low, according to the authors' assessment (Figs. 2 and 3).

Pain score at 6, 12, and 24 h

The forest plot diagrams (Figs. 4, 5, and 6) showed that compared with methods for thoracic wall analgesia and PCA, the SAPB group result in a significant decrease in pain scores (mean difference = − 1.39 [− 2.24, − 0.54]; 95% CI; I^2 = 92%; P = 0.001) (Fig. 4), (mean difference =

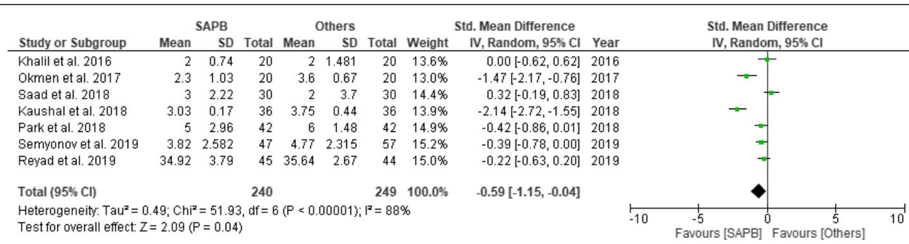

Fig. 5 Pain score at 12 h

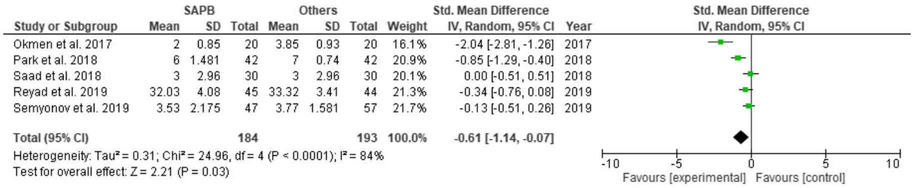

Fig. 6 Pain score at 24 h

– 0.59 [– 1.15, – 0.04]; 95% CI; I^2 = 88%; P = 0.02) (Fig. 5), and (mean difference = – 0.61 [– 1.14, – 0.07]; 95% CI; I^2 = 84%; P = 0.03) (Fig. 6).

Analgesia consumption

The forest plot demonstrates the significant decrease in consumption of analgesic drugs in SAPB group ((mean difference = – 15.3788 – 20.1931, – 10.5645]; 95% CI; I^2 = 98%; P = 0.00001) (Fig. 7).

Nausea and vomiting

Application of SABP resulted in a significant decrease in the incidence of N&V (RR = 0.44 [0.26, 0.76] 95% CI; I^2 = 7%; P = 0.003) (Fig. 8).

Incidence of hypotension

Forest plot demonstrates no difference in the incidence of hypotension (RR = 0.80 [0.56, 1.15] 95% CI; I^2 = 53%; P = 0.23) (Fig. 9).

Discussion

Various regional anesthetic techniques such as TEA, TPVB, local wound infiltration, and ultrasound-guided fascial plane blocks have been utilized to provide postoperative analgesia in thoracic surgeries. These techniques not only manage acute postoperative pain but also help prevent chronic post-surgical pain (Garg, 2017).

The basic SAPB involves L.A. injection into a fascial plane that may be either superficial or deep into the serratus anterior muscle (Mayes et al., 2016).

The SAPB may be performed anywhere in an area bounded by the anterior axillary line and posterior axillary line, and the second to seventh ribs. Both superficial and deep SAPB primarily target the lateral cutaneous branches of intercostal nerves. The actual nerves involved being determined mainly by the exact point of injection and the volume of injectate (Durant et al., 2017).

However, the efficacy of the SAPB in thoracotomy and rib fractures suggests that it may also anesthetize deeper structures. The long thoracic nerve and thoracodorsal nerve also run in the superficial serratus anterior muscle plane and maybe inadvertently or deliberately anesthetized by a superficial SAPB (Kunio et al., 2018).

The results of this meta-analysis indicate that investigations into the serratus anterior plane block in cardiothoracic surgery and trauma are still at an early stage.

Ten studies were identified for inclusion in this study, involving a total of 735 patients, of which eight were RCTs. Nine trials evaluated the SAPB in the setting of video-assisted thoracoscopic surgery (five studies) and thoracotomy (four studies).

One trial evaluated the SAPB in pediatric cardiac surgery. Five of these compared it with IV analgesia alone, and two compared it with the TPVB. One compared it with PECS two blocks and with intercostal nerve blocks and one compared it with surgically placed continuous TPVB. Only one study compared it with TEA.

One study comparing a serratus anterior catheter with a thoracic epidural catheter with levobupivacaine infusion (Khalil et al., 2017), another study assessed SABP as an adjuvant to PCA analgesia (Reyad et al., 2019).

Nevertheless, the available evidence to date is encouraging for the efficacy of SAPB in cardiothoracic surgery.

Regarding the clinical duration of postoperative analgesia in the different trials included in this study, we

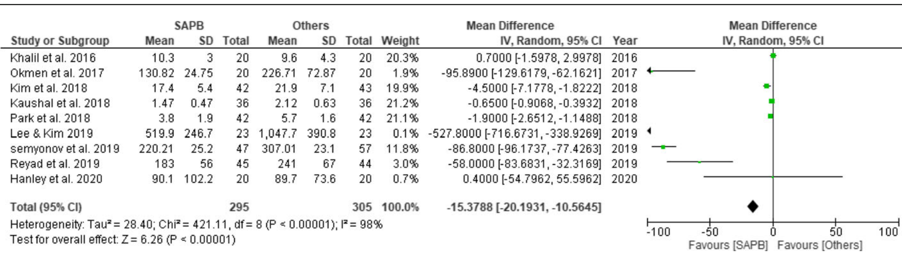

Fig. 7 Analgesia consumption

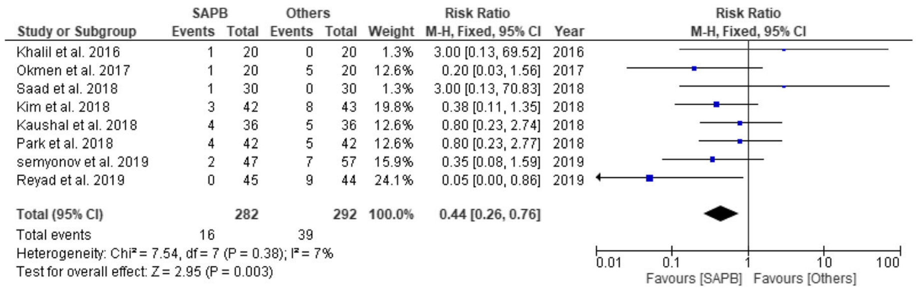

Fig. 8 Nausea and vomiting

found that SAPB appears in the region of the first 6 h, 12 h, up to 24 h as adequate analgesia in comparison to different analgesic methods.

As a result of the analgesic benefit of SAPB over the first postoperative 24 h, the total doses of analgesic consumption over the first postoperative day are lower than the other analgesic methods for anterolateral thoracic wall incisions and trauma.

Less analgesic requirements related to SAPB lead to decreased side effects of analgesic consumption, especially nausea and vomiting. Nausea and vomiting are common side effects related to increased opioids consumption as rescue analgesia or related to pain-producing stress gastritis.

Although SAPB is an interfacial plane block with a lack of sympathetic block, there is no difference in hemodynamic changes compared to different analgesic methods.

There were two recent meta-analyses (Zhang et al., 2020; Liu et al., 2020) discussing the role of SAPB after cardiac surgery. The first one by Zhang et al., assessing analgesic Effectiveness of perioperative ultrasound-Guided SAPB combined with general anesthesia in patients undergoing video-assisted thoracoscopic surgery VATS, included one retrospective study and three randomized controlled with just 262 patients. Zhang et al. confirmed the postoperative analgesic effectiveness of ultrasound-guided perioperative SAPB on patients undergoing VATS at different times in the PACU and the ward. Although it had better patient satisfaction with analgesia, the study found no advantage in side effects, chest tube removal, or hospital length of stay (Zhang et al., 2020).

Liu et al. study included eight randomized controlled studies with 542 discussing the postoperative analgesic efficacy of SAPB for thoracic surgery. Liu et al. concluded the SAPB could provide adequate anesthesia for thoracic surgery and reduce postoperative opioids consumption. Also, the SAPB will decrease the side effects of PONV.

Zhang et al. and Liu et al. both confirmed the results of our study. Still, our study included a large number of studies (10 studies) with 735 patients assessing for postoperative analgesia for thoracotomy, VATS, and thoracic wall trauma.

First, these are relatively novel techniques, and we were able to discover only a small number of RCTs involving just over 735 patients. Most of the current literature comprises small, randomized studies, a limited number of studies evaluating continuous regional analgesia blocks.

There are several questions that should be evaluated regarding the safety of SAPB as pleural puncture, risk of hematoma formation, especially in anti-coagulated patients with the assessment of ease of performance of SAPB in comparison to different regional techniques for anterolateral thoracic wall incision.

These questions need more analysis to complete the validity of SAPB as the most effective and safe anterolateral wall regional block.

Finally, many clinically relevant questions have yet to be adequately addressed. These include the first time of

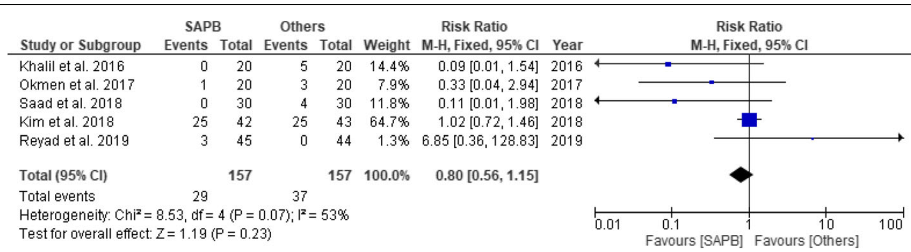

Fig. 9 Number of patients developed hypotension

rescue analgesia, analgesic consumption, side effects as nausea and vomiting and finally, hemodynamic changes as hypotension offered by SAPB.

Conclusions

Research into the use of serratus anterior plane block in cardiothoracic surgery and trauma is still at an early stage. Nevertheless, the current evidence indicates that this block may be a safe and effective option for antero-lateral thoracic analgesia, mainly where more invasive techniques such as TEA or TPVA are not feasible. Further, comparative trials are needed to determine which method offers the optimal benefit-to-risk ratio in specific surgical settings.

Abbreviations

IOR: Interquartile range (IQR); L.A.: Local anesthetics; PACU: Postanesthesia care unit; PCA: Patient controlled analgesia; Pecs I: Pectoral block type 1; Pecs II: Pectoral block type 2; PONV: Postoperative nausea and vomiting; RCTs: Randomized controlled trial; SABP: Serratus anterior plane block; TEA: Thoracic epidural analgesia; TPVB: Thoracic paravertebral blockade (TPVB); U.S.: Ultrasound; VATS: Video-assisted thoracoscopic surgery

Acknowledgements

Not applicable.

Authors' contributions

AM and TA conceived, planned, and designed the study. DH, TA, and BM revised literatures collect the data, and searched for the included clinical trials. AM, BM, and DH assessed the quality, risk of bias of the included trials, and performed the analysis. All authors assessed, wrote, reviewed the manuscript, and approved the final version of the manuscript.

Funding

None.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

All authors declare that they have no competing interests.

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