ABSTRACT
Background Serratus anterior plane block (SAPB) has gained popularity in cardiothoracic surgery due to its feasibility and simplicity. However, the efficacy of ultrasound-guided single-injection SAPB in the paediatric population has not been well evaluated, as only a few studies with small sample sizes are available.

Methods We searched PubMed, Embase (Ovid), Cochrane Central Register of Controlled Trials, Wanfang databases and China National Knowledge Infrastructure from their inception to 31 September 2022 for randomised comparative clinical trials that compared single-injection SAPB with systemic analgesia or different forms of regional analgesia in children. The primary outcomes included postoperative opioid consumption and pain scores within 24 hours. The secondary outcomes included postoperative adverse events, the need for rescue analgesia and the time from the end of surgery to endotracheal tube removal.

Results Five randomised controlled trials with 418 children meeting the inclusion criteria were included. SAPB markedly reduced postoperative opioid consumption up to 24 hours compared with controls (mean difference (MD): −0.29 mg/kg, 95% CI −0.38 to −0.20, ²I=67%). The postoperative pain scores were reduced compared with controls: 1 hour (MD −0.6, 95% CI −1.17 to −0.04, ²I=92%), 4–6 hours (MD −1.16, 95% CI −1.87 to −0.45, ²I=90%) and 12 hours (MD −0.71, 95% CI −1.35 to −0.08, ²I=86%). The incidence of postoperative nausea and vomiting was comparable between SAPB and controls. One trial suggested that the analgesic effect of SAPB was comparable to that of ICNB (intercostal nerve block).

Conclusion Single-injection SAPB is associated with a reduction in opioid consumption and pain intensity after cardiothoracic surgery via thoracotomy in children. Due to the high heterogeneity, the Grading of Recommendations Assessment, Development and Evaluation scores were low. Clinical trials with rigorous methodological approaches as well as safety endpoints are needed to confirm these preliminary findings.

WHAT IS ALREADY KNOWN ON THIS TOPIC
⇒ In adults, serratus anterior plane block (SAPB) is effective in reducing pain during thoracotomy and video-assisted thoracoscopic surgery.
⇒ By using ultrasound, SAPB is considered a promising fascial plane block for paediatric cardiothoracic surgery performed through anterolateral incisions. However, scientific evidence was lacking.

WHAT THIS STUDY ADDS
⇒ SAPB provided a reduction in opioid consumption and pain score in the first 24 hours in children after cardiothoracic surgery via thoracotomy.
⇒ SAPB may be considered as a promising option in clinical practice to treat postoperative thoracotomy pain in children.
⇒ However, with high heterogeneity, the findings should be interpreted cautiously.

INTRODUCTION
The management of acute postoperative pain remains a challenge in the cardiothoracic surgical population. Over 80% of children endure moderate-to-severe persistent pain after surgery, with 23% of thoracotomy patients in the population of children developing chronic pain over time.1 For the paediatric population, it may have a serious impact on the quality of life in the future.

Regional analgesia has been widely adopted as an important part of multimodal analgesia.2 Currently, adopting thoracic epidural analgesia intervention as a norm and strategy for paediatric patients in cardiothoracic surgery is still controversial because of the occurrence of complications.3 In addition, due to smaller anatomical structures, thoracic epidural blocks for children should be performed with fine meticulous techniques. Throughout the last decade, the use of ultrasound has led to...
the refinement and application of regional nerve blocks in children.\(^4\) Since first described in 2013,\(^5\) ultrasound-guided serratus anterior plane block (SAPB) has gained popularity as a promising fascial plane block due to its technically simple, relatively safe and analgesia of ipsilateral hemithorax.\(^6\)\(^7\) It blocks the lateral cutaneous branches of the second to ninth spinal nerves by administering local anaesthetic above or below the serratus anterior muscle under ultrasound guidance, which provides analgesia of the ipsilateral hemithorax. The incidence of adverse effects associated with fascial plane block is reported to be lower than that associated with neuraxial blockade.\(^8\)\(^9\)

In paediatric populations, as distinct anatomical and physiological concerns from adults, the application of ultrasound-guided SAPB has not been well evaluated, and systematic reviews and meta-analyses of the procedure are lacking. Therefore, we aim to conduct a systematic review and meta-analysis on the benefits and safety of SAPB for postoperative analgesia in children.

**METHODS**

In preparing this article, the authors adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement guidelines\(^1\) and registered the protocol in the PROSPERO database.

**Search strategy**

A systematic search in the following electronic databases, PubMed, Embase (Ovid), Cochrane Central Register of Controlled Trials, Wanfang databases and China National Knowledge Infrastructure, from their inception to 31 September 2022 was conducted by two reviewers (YH and ZL). Appropriate controlled vocabulary terms and subject headings aimed at capturing articles relating to ‘Serratus anterior plane block’ and ‘child’ were applied. The full search strategy for these databases is listed online supplemental appendix 1. The reference lists of all included studies were also manually checked to identify additional trials that satisfied the criteria. We did not place any restrictions based on language or types of surgery.

**Eligibility criteria/study selection criteria**

An initial review of the titles and abstracts of retrieved articles was conducted by two review authors (YH and ZL) independently to exclude duplicate and non-relevant studies. Discrepancies were resolved by discussion or involvement of the third review author (MX) until consensus was reached. The full texts of the remaining articles were obtained for further evaluation. Randomised comparative clinical studies that included paediatric patients (less than 18 years) having any surgery in which SAPB was administered separately in at least one group for postoperative analgesia as the intervention and systemic analgesia or different forms of regional analgesia as the comparator were considered. The primary outcomes for evaluating analgesic efficacy included postoperative opioid consumption and pain scores within 24 hours after endotracheal tube removal. The secondary outcomes included postoperative adverse events, such as nausea and vomiting, block-related complications, the need for rescue analgesia and time from the end of surgery to endotracheal tube removal. Conference papers/abstracts, single-case studies, editorial letters and reviews were excluded.

**Data extraction**

Two reviewers (ZL and MX) extracted all the data independently using Excel spreadsheets (Microsoft). Continuous outcomes were reported as the means with SDs. The data represented as medians and ranges were converted to means and SDs according to the methods described before.\(^10\) In the case of missing data or graphically presented data, we attempted to contact the corresponding author by mail. If no response was received, data from figures were extracted with WebPlotDigitizer software.\(^11\) The information from trials was collected as follows: the first author’s name, publication year, sample size, demographic characteristics of participants (age, sex, weight and height or body mass index), nature of surgery performed, duration of surgery time, mode of anaesthesia used, opioid consumption, all pain scores (static) within 24 hours on a 0–10 scale (if they were based on a 0–10 scale, they were assumed equivalent), the need for rescue analgesics or time of rescue request, adverse events and length of hospital discharge times.

**Assessment of study quality and risk of bias**

Two reviewers (ZL and MX) subsequently read all studies and independently evaluated the quality. The Cochrane Collaboration’s risk of bias tool\(^12\) (V.2, RoB 2) was used to assess the methodological quality of randomised controlled trials (RCTs). Any disagreements were settled through discussion, if needed, involving another reviewer, the author (YH).

**Evidence assessment**

The quality of evidence for each outcome was evaluated using the Grading of Recommendations Assessment, Development and Evaluation criteria.\(^13\) The outcomes of each RCT were rated as ‘high quality’ evidence. Then, the quality was downgraded to moderate, low or very low by any serious study limitation(s), including indirectness, imprecision, inconsistency, risk of bias and publication bias.

**Statistical methods**

A quantitative random-effects meta-analysis was conducted using RevMan V.5.4 (Foundation for Statistical Computing, Vienna, Austria) when data for each outcome were available from two or more randomised controlled trials. It was intended a priori to pool data from trials with the same comparator, assessing similar outcomes and at comparative time points.
Heterogeneity was assessed using the $I^2$ statistic (low: 25%–49%, moderate: 50%–74% and high: ≥75%). If considerable heterogeneity was found, we excluded one study at a time to identify plausible sources of heterogeneity. Subgroup analysis or sensitivity analysis was performed to identify the potential cause of the heterogeneity if possible. A fixed-effect model was chosen if low heterogeneity ($I^2 < 50\%$) was found to represent the best estimate of the intervention effect. Otherwise, a random-effects model was preferred.

The inverse variance model was used to calculate a standardised mean difference or a weighted mean difference with 95% CIs for continuous data. For dichotomous variables, the Mantel-Haenszel model was used, resulting in risk ratios (RRs) with related 95% CIs. A p value less than 0.05 was considered to be statistically significant. Potential publication bias was tested by inspection of funnel plots when more than 10 trials were included.

**RESULTS**

The PRISMA diagram (figure 1) illustrates the screening process and depicts how many articles were included and excluded at each stage of bibliographic searches. A total of 70 initial article citations were identified from the literature search. After removing duplicates, 44 potential publications were assessed for further examination of their titles and abstracts. Of these, the full text of eight studies was examined for eligibility, and five RCTs were included in this systematic review. The extraction agreements were consistent with those of the two reviewers.

**Study characteristics**

From five RCTs, 418 children who underwent cardiothoracic surgery met the inclusion criteria, and quantitative analyses were conducted. Table 1 summarises the characteristics of each study. Two studies involved paediatric cardiothoracic surgery including lung cyst excision, lobectomy, ligation of persistent ductus arteriosus, repair...
of aortic coarctation or modified Blalock-Taussig shunt via thoracotomy,15 19 two studies involved novel minimal access cardiac surgery, 16 17  and one study involved ear reconstruction after costal cartilage harvest in children.18

The type, volume and concentration of local anaesthetics injected varied in each trial. Validated 0–10 pain scales, such as FLACC (faces, legs, activity, cry, consolability), MOPS (modified objective pain score) and NRS (numeric rating scales), were used. They were assumed to be equivalent in our quantitative analysis. All included studies had comparable baseline characteristics and assessed the analgesic effects of SAPB, and three studies compared it with placebo,15–17 one with incision infiltration18 and one with another regional block.19

Study assessment
The results of the risk of bias assessment of each study are displayed in figure 2. In some of these trials, whether allocation concealment and blinding of personnel had been implemented was unclear, potentially resulting in selection and performance biases. No author responded with the necessary details on trial methodology or missing data when we asked for clarification.

Quantitative synthesis
Forest plots summarising the common results are shown in figure 3. For each outcome, table 2 summarises the evidence profiles and the specific grading of certainty for the main outcomes. The majority of outcomes were rated as low in certainty of evidence due to the high risk of bias associated with allocation concealment, blinding of personnel and some other bias, such as heterogeneity or imprecision. Sensitivity analyses or publication bias were not conducted due to the small number of studies.

Table 1 Study characteristics of the included trails

<table>
<thead>
<tr>
<th>Reference</th>
<th>Year</th>
<th>Subjects number</th>
<th>Type of surgery</th>
<th>Local anaesthetic administered</th>
<th>Control</th>
<th>Age</th>
<th>Primary outcome</th>
<th>Adverse event</th>
<th>Pain scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gado et al15</td>
<td>2022</td>
<td>70 Unilateral thoracotomy</td>
<td>Bupivacaine 0.125% 0.4 mL/kg; unilateral SAPB</td>
<td>No block</td>
<td>6 months to 3 years</td>
<td>Postoperatively fentanyl in 24 hours</td>
<td>PONV</td>
<td>FLACC</td>
<td></td>
</tr>
<tr>
<td>Kaushal et al19</td>
<td>2019</td>
<td>72 Cardiac surgery through a thoracotomy</td>
<td>Ropivacaine 0.2% 3 mg/kg; unilateral SAPB</td>
<td>ICNB</td>
<td>6 months to 10 years</td>
<td>MOPS</td>
<td>NS</td>
<td>MOPS</td>
<td></td>
</tr>
<tr>
<td>Chen et al18</td>
<td>2022</td>
<td>58 Costal cartilage harvest through a thoracotomy</td>
<td>Ropivacaine 0.25% 3 mg/kg; bilateral SAPB</td>
<td>II</td>
<td>5–12 years</td>
<td>NRS</td>
<td>PONV opioid-related adverse</td>
<td>NRS</td>
<td></td>
</tr>
<tr>
<td>Jing et al16</td>
<td>2020</td>
<td>150 Cardiac surgery through a thoracotomy</td>
<td>Ropivacaine 0.2% 3 mg/kg; unilateral SAPB</td>
<td>Sham block</td>
<td>2–8 years</td>
<td>FLACC</td>
<td>PONV</td>
<td>FLACC</td>
<td></td>
</tr>
<tr>
<td>Xiao and Ma17</td>
<td>2021</td>
<td>68 Cardiac surgery through a thoracotomy</td>
<td>Ropivacaine 0.3% 0.5 mg/kg; unilateral SAPB</td>
<td>No block</td>
<td>1–5 years</td>
<td>FLACC</td>
<td>PONV</td>
<td>FLACC</td>
<td></td>
</tr>
</tbody>
</table>

FLACC, the face, legs, activity, cry, consolability behavioural tool; ICNB, intercostal nerve block; II, incision infiltration; MOPS, modified objective pain scoring method; NRS, numeric rating scales; NS, not statistically significant; PONV, postoperative nausea and vomiting; SAPB, serratus anterior plane block.

Figure 2 Summary of bias evaluated by the risk of bias 2 tool. D, bias arising from deviations from the intended interventions; Me, bias in measurement of the outcome; Mi, bias result of missing outcome data; R, bias due to randomisation process; S, bias in selection of the reported result. Green (+), yellow (!) and red (-) circles indicate low, unclear and high risk of bias, respectively.
Postoperative opioid consumption

Compared with systemic intravenous analgesia, SAPB significantly reduced opioid consumption up to 24 hours postoperatively in three of these four studies.\textsuperscript{15–18} Pooled trials also showed lower opioid consumption 24 hours postoperatively (−0.29 mg/kg, 95% CI −0.38 to −0.20, \(p<0.00001\), \(\bar{I}^2=67\%\), figure 3A). The quality of evidence for this outcome is low. Compared with intercostal nerve block (ICNB), SAPB also decreased opioid consumption up to 24 hours (mean difference (MD) −0.65, 95% CI −0.91 to −0.39, \(p=0.002\), see online supplemental appendix 2A).\textsuperscript{19}

Postoperative pain score

Based on the data heterogeneity, a random effect model was used to analyse the postoperative pain score. A significant reduction in static pain scores was observed in subjects who received SAPB after surgery at 1 hour (MD −1.50, 95% CI −2.17 to −0.83, \(\bar{I}^2=67\%\), figure 3B), 4–6 hours (MD −1.16, 95% CI −1.87 to −0.45, \(\bar{I}^2=90\%\), figure 3B) and 12 hours (MD −0.71, 95% CI −1.35 to −0.08, \(\bar{I}^2=86\%\), figure 3B). At 24 hours after endotracheal tube removal, static pain scores were comparable between the two groups (MD −0.20, 95% CI −0.40 to 0.06, \(\bar{I}^2=0\%\)). Due to significant heterogeneity and inconsistency, the outcome results were regarded as very low quality. Compared with ICNB,\textsuperscript{19} pain intensity was lower at 6 hours and 12 hours after endotracheal tube removal (\(p<0.001\), see online supplemental appendix 2B).

Rescue analgesics

Three studies assessed rescue analgesia; however, there were too many definitional differences among each study, such as the number of people requiring rescue analgesia,\textsuperscript{18} the duration of the first rescue analgesia\textsuperscript{15} and the times of patient-controlled analgesia (PCA) compressions.\textsuperscript{17} Accordingly, a meaningful quantitative assessment of this variable was precluded due to the heterogeneity of definitions in studies. Even so, it is noticeable...
Table 2  Quality of the evidence based on the GRADE method

<table>
<thead>
<tr>
<th>SAPB versus no block</th>
<th>Outcomes</th>
<th>Risk of bias</th>
<th>Inconsistency</th>
<th>Indirectness</th>
<th>Imprecision</th>
<th>Publication bias</th>
<th>Mean difference or relative effect (95% CI)</th>
<th>No of participants (studies)</th>
<th>Quality of the evidence (GRADE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opioid consumption 24 hours postoperatively</td>
<td>Serious*</td>
<td>Serious†</td>
<td>No serious indirectness</td>
<td>Serious‡§</td>
<td>Undetected</td>
<td>−0.29 (−0.38 to −0.20)</td>
<td>278 (three studies)</td>
<td>⊕⊕⊕⊕ very low*†‡§</td>
<td></td>
</tr>
<tr>
<td>Static pain score after extubation at 1 hour</td>
<td>Serious*</td>
<td>Very serious†</td>
<td>No serious indirectness</td>
<td>Serious‡§</td>
<td>Undetected</td>
<td>−0.6 (−1.17 to −0.04)</td>
<td>346 (four studies)</td>
<td>⊕⊕⊕⊕ very low*†‡§</td>
<td></td>
</tr>
<tr>
<td>Static pain score after extubation at 4–6 hours</td>
<td>Serious*</td>
<td>Very serious†</td>
<td>No serious indirectness</td>
<td>Serious‡§</td>
<td>Undetected</td>
<td>−1.16 (−1.87 to −0.45)</td>
<td>138 (two studies)</td>
<td>⊕⊕⊕⊕ very low*†‡§</td>
<td></td>
</tr>
<tr>
<td>Static pain score after extubation at 12 hours</td>
<td>Serious*</td>
<td>Very serious†</td>
<td>No serious indirectness</td>
<td>Serious‡§</td>
<td>Undetected</td>
<td>−0.71 (−1.35 to −0.08)</td>
<td>276 (three studies)</td>
<td>⊕⊕⊕⊕ very low*†‡§</td>
<td></td>
</tr>
<tr>
<td>Static pain score after extubation at 24 hours</td>
<td>Serious*</td>
<td>No serious inconsistency</td>
<td>No serious indirectness</td>
<td>Serious‡§</td>
<td>Undetected</td>
<td>−0.2 (−0.4 to −0.01)</td>
<td>276 (three studies)</td>
<td>⊕⊕⊕⊕ low*‡§</td>
<td></td>
</tr>
<tr>
<td>PONV</td>
<td>Serious*</td>
<td>Serious†</td>
<td>No serious indirectness</td>
<td>Serious‡§</td>
<td>Undetected</td>
<td>RR 0.81 (0.41 to 1.59)</td>
<td>346 (four studies)</td>
<td>⊕⊕⊕⊕ very low*†‡§</td>
<td></td>
</tr>
</tbody>
</table>

SAPB versus ICNB

| Opioid consumption 24 hours postoperatively | Very serious* | No serious inconsistency | No serious indirectness | Very serious†‡ | Undetected | −0.65 (−0.91 to −0.39) | 72 (one study) | ⊕⊕⊕⊕ very low*‡§ |
| Static pain score after extubation at 6 hours | Serious* | No serious inconsistency | No serious indirectness | Serious† | Undetected | −0.50 (−0.71 to −0.39) | 72 (one study) | ⊕⊕⊕⊕ low*‡§ |
| Static pain score after extubation at 12 hours | Serious* | No serious indirectness | No serious indirectness | Serious† | Undetected | −0.86 (−1.00 to −0.72) | 72 (one study) | ⊕⊕⊕⊕ low*‡ |

*Downgraded the quality of evidence by one level due to serious/very serious limitations in design or execution.
†Due to substantial statistical heterogeneity of $I^2 > 30\%$, the quality of evidence downgraded by one/two levels.
‡Downgraded by one level because of relatively few patients and few events.
§Downgraded the quality of evidence by one level arising from a wide CI of the results.

GRADE, Grading of Recommendations Assessment, Development and Evaluation; ICNB, intercostal nerve block; PONV, postoperative vomiting and nausea; RR, risk ratio; SAPB, serratus anterior plane block.
that all the trials showed significant differences in the need for rescue analgesia between controls and SAPB.

**Time to endotracheal tube removal**
A total of two studies reported that the time from the end of surgery to endotracheal tube removal did not show a significant difference between groups.18 19 Due to the limited pooled data, quantitative analysis was not performed.

**Postoperative adverse events and complications**
In each study, nausea and vomiting were assessed as postoperative adverse effects. According to our analysis, there was no significant difference between groups (RR 0.81, 95% CI 0.41 to 1.59, p=0.53, $I^2=60\%$, figure 4).15–18 We rate the quality of evidence to be low for this outcome because of inconsistency and heterogeneity.

Perioperative haemodynamics between the two groups were also found to be not significantly different within 24 hours in two studies.18 19 The use of SAPB did not influence respiratory complications in one study.19 In light of the absence of more than two RCTs, meta-analysis was impossible for these outcomes.

**DISCUSSION**
Our quantitative systematic review shows that single-injection SAPB added to general anaesthesia in children was associated with a reduction in analgesic consumption following anterolateral thoracic surgeries via thoracotomy within 24 hours postoperatively and a slight decline in static pain scores 1, 4–6 and 12 hours after surgery, but differences were not found in the incidence of PONV. The quality of evidence was graded as low and very low.

It is of the utmost importance to adequately manage perioperative pain to minimise patients’ discomfort and potentially limit postoperative complications. We found the SAPB’s overall pooled reduction in pain score was between 0.6 and 1.17, there appears to be a small minimal clinically important difference (MCID)20 21. However, clinically relevant postoperative pain intensity has been reported to be reduced by SAPB in adults undergoing video-assisted thoracoscopic surgery (VATS).2 However, it might be taken into consideration that objectively evaluating children’s pain intensity is challenging because children may have more difficulties expressing and quantifying pain than adults, and there is no standardisation of pain assessment tools, so pooling of data is challenging because no individual scoring system will be suitable for assessing pain in all children and in all contexts.22 23 Also, pain trajectories vary depending on the type of surgery, and follow different slopes.24 When assessing pain control, the relationship between the incision and the intensity of pain should be taken into account. The surgical incision of all the five studies we reviewed were in anterolateral thoracic wall including thoracotomy (two study) and costal cartilage harvest (one study) and minimally invasive cardiac surgery (two studies). Even in minimally invasive cardiac surgery conducted by a mini-thoracotomy approach, the thoracotomy exposure, because of rib extractions, muscle dividing and intercostal nerve injuries, can have significant pain. Compared with thoracotomy, VATS has been found to be less painful and less need for analgesic medications.25 In this case, SAPB might be more advantageous in minimal access thoracoscopic approaches. Further investigation to describe benefits of SAPB in children is needed. Using the right duration of regional analgesia for the right surgical population, we may be able to move beyond immediate postoperative pain and 24-hour opioid use in regional anaesthesia research studies and focus on improving more important clinical outcomes such as pediatric ICU/hospital stay length, time for refeeding and physical activity after surgery.

The study found a remarkable reduction in opioid consumption postoperatively in a paediatric population with satisfactory analgesia compared with the control group, regardless of whether local anaesthetic infiltration was coadministered. Large doses of opioids can cause adverse effects, including respiratory depression, oversedation, nausea, vomiting and urinary retention, all of which can occur during prolonged mechanical ventilation.26 27 PONV was demonstrated to be a consequence of reduced opioid use and appeared to be reduced by SAPB in adults and some trials in children.16 18 28 Note-worthy, not the same as previously reported,29 our pooled data suggested that there was no reduction in the incidence of PONV or time to endotracheal tube removal.

**Figure 4** Forest plot of postoperative vomiting and nausea. SAPB, serratus anterior plane block.
It is possible that the results are due to heterogeneity and inconsistency among the studies since the samples of the included trials were small or because of other confounding factors. The low incidence of PONV among paediatric patients might influence the outcome. The time to endotracheal tube removal may vary depending on the type of surgery; however, we included all studies regardless of the type of surgery.

Regarding the length of hospital stay, pain intensity and opioid consumption are not the main factors, especially for children after cardiac surgery. Comparisons were difficult due to the different discharge protocols between institutions. It is likely that trial diversity reflects what is present in clinical practice. Nonetheless, given the diversity seen, it is important to strengthen a framework for standard procedures.

As far as our analyses are concerned, no complications associated with nerve blocks, such as local anaesthetic toxicity or pneumothorax, have been identified. The findings suggested the feasibility of SAPB analgesia in children. Limited high-quality evidence in our analyses suggests that SAPB is associated with a decreased incidence of hypotensive episodes. More research focusing on this topic is required to investigate the influence of SAPB on haemodynamics in comparison to other techniques.

In light of these findings, it is controversial to generalise SAPB’s clinical utility as an opioid-saving method in this patient population. Our findings may allow clinicians to balance the benefits and risks of regional analgesia.

There are limitations to our study that deserve discussion. As a first point, although all the studies under investigation are RCTs with similar key characteristics (methodology and main outcome), the study heterogeneity for several variables is high, which limits and weakens the strength of our conclusions. Sensitivity analyses were not performed due to the limited number of eligible studies. Second, as a result of the small sample size, poor blinding method and allocation concealment, further large-sized and well-designed RCTs are needed. In addition, the variation in intraoperative opioid dosage is a possible confounder that could influence the postoperative opioid dose and adverse events.

Fourth, the volume and concentration of local anaesthetics injected varied in each trial, which may be another confounder influencing the analgesia effects. In addition, it is also worth investigating the optimal dosage of local anaesthetics used for certain peripheral nerve blocks in children. Fifth, since postoperative pain assessment in published trials is not standardised in most cases for children, establishing a standardised framework for evaluating postoperative pain would improve consistency.

In light of Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials’s (IMMPACT) suggestion for pediatric patients that the core measurement of pain clinical trial outcomes should take into account not only pain intensity, but physical/emotional functioning, symptoms and adverse events, satisfaction with treatment, sleep and economic factors as well, clinicians may benefit from these recommendations and prevent the need to subject children to clinically irrelevant pain trials. Additionally, the MCID of pain score in the paediatric population is worthy of discussion. Last, the present evidence for the comparison between SAPB and other types of thoracic nerve block is limited.

CONCLUSION

Based on the results of this meta-analysis and systematic review, single-injection SAPB is associated with a reduction in opioid consumption and may be a safe and effective option for management of postoperative thoracotomy pain after paediatric cardiothoracic surgery through anterolateral thoracic incision. These findings should be interpreted cautiously since they are based on a meta-analysis of small and heterogeneous studies. As a result, research into the application of SAPB in paediatric cardiothoracic surgery through thoracotomy is still at an early stage. Clinical trials with rigorous methodological approaches as well as safety endpoints are needed to confirm SAPB’s benefits in this patient population.

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Contributors YH and YXZ conceived the idea for this systematic review. All authors (YH, ZL, MX, BD and YXZ) developed the methodology for the systematic review. The manuscript was drafted by YH, and reviewed by BD and YXZ. ZL and MX will screen potential studies, and perform duplicate independent data abstraction. YH and MX will undertake a risk of bias assessment and assess the evidence quality. YH and MX will conduct the data synthesis. All authors contributed to the research and agreed to be responsible for all aspects of the work.

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