Analogic efficacy and safety of thoracic paravertebral and epidural analgesia for thoracic surgery: a systematic review and meta-analysis

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Abstract

Though once considered the gold standard, epidural anaesthesia has complications that may be significant and include hypotension, urinary retention, partial or patchy block and, in rare cases, devastating neurological injuries also. Paravertebral block (PVB) is an alternative technique for unilateral surgical procedures like thoracotomy, which may offer similar analgesic effectiveness and a more favourable side-effect profile than epidural anaesthesia. This systematic review and meta-analysis of published randomized clinical trials aims to compare thoracic paravertebral with thoracic epidural analgesia (TEA) in thoracotomy for lung surgery. Five hundred and forty-one patients from 12 clinical trials have been included in this systematic review and meta-analysis. We found that visual analogue scale (VAS) scores at rest and during activity/coughing at 4–8, 24 and 48 h postoperatively were similar in both the PVB and TEA groups. Considering studies not included in the previous meta-analysis, a VAS score on activity at 48 h is significantly better in the PVB group (mean difference 0.40 cm; 95% confidence interval [95% CI] 0.77, 0.02; Mantel-Haenszel (M-H) fixed). Hypotension (odds ratio 0.13; 95% CI 0.06, 0.31; M-H fixed) and urinary retention are more common in the epidural analgesia group. So, we conclude that thoracic PVB may be as effective as thoracic epidural analgesia for post-thoracotomy pain relief and is also associated with fewer complications.

Keywords: Thoracic epidural • Thoracic paravertebral • Thoracotomy • Post-thoracotomy pain

INTRODUCTION

Thoracotomy is one of the most painful surgeries and is also associated with significant postoperative diaphragmatic dysfunction and respiratory compromise [1]. Thoracic epidural analgesia (TEA) is the most commonly used modality of postoperative pain management in thoracotomy patients and was once considered to be the ‘gold standard’ [2, 3]. Epidural analgesia may attenuate the surgical stress response and provide a favourable haemostatic milieu in terms of endocrine, coagulation, gastrointestinal and immune function [4]. However, TEA at times may be associated with important clinical complications such as hypotension, urinary retention and even pulmonary complications from respiratory muscle weakness [5], and may also be associated with worse outcome after pneumonectomy [6]. Thoracic paravertebral block (PVB) may be a suitable alternative in thoracotomy patients, where only a unilateral sensory block is desirable [7]. However, the available data from clinical studies on the efficacy of PVB in postoperative pain management after thoracotomy are controversial, and all the individual randomized clinical trials (RCTs) have compared a small number of patients, and ineffectiveness of PVB after thoracotomy has also been reported [8].

Local anaesthetic injection in the paravertebral space produces primarily unilateral sensory and motor block, which is advantageous for unilateral surgical procedures of the chest and abdomen such as thoracotomy, breast surgeries and renal surgeries. Catheters for postoperative pain management can also be placed during surgery under direct vision of the surgeon before thoracotomy closure as described by Helms et al. [8]. A previous meta-analysis by Davies et al. [9] found that PVB provides analgesia that is comparable to TEA with fewer complications, and a systematic review [10] was unable to conclude whether or not PVB is effective in post-thoracotomy pain management. Since the previous meta-analysis, seven randomized trials comparing the efficacy of PVB with that of TEA in post-thoracotomy pain management have been published in the literature. We therefore decided to undertake a systematic review and meta-analysis on this issue to ascertain whether PVB is comparable to the so-called gold standard TEA and whether or not it is safer.

Methods

Two authors (D.K.B. and P.K.) independently did an electronic search in the following databases: PubMed, PubMed Central, Scopus, Google Scholar and Cochrane Central Register of Controlled Trials (CENTRAL) with the following keywords: ‘thoracic paravertebral’, ‘thoracotomy’, ‘thoracic epidural’, ‘thoracic epidural analgesia’, ‘thoracic epidural anaesthesia’ and ‘paravertebral block’. The electronic search was done on 18 August 2013. Details of the PubMed search strategy have been provided in Supplementary Material, Appendix 1. We included the RCTs published in the English language comparing the efficacy of PVB with that of TEA after thoracotomy for lung surgery. Patients

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undergoing thoracotomy for non-lung surgery such as cardiac surgery, lumbar epidural anaesthesia/analgesia, and where only epidural opioid regimens were used, were excluded. Both methods of insertion of paravertebral catheter, i.e. whether before surgery by the anaesthesiologist or just before thoracotomy closure by the surgeon, were included in the analysis. Extra-pleural intercostal nerve block has also been described as a technique for post-thoracotomy pain management. However, as significant differences exist in technical considerations between the PVB and extra-pleural intercostal nerve block, this technique has not been included for analysis here. Two authors (D.K.B. and P.K.) independently selected eligible trials to be included, and disagreement between them was resolved by discussion with a third author (S.M.).

Quality assessment

The included clinical studies were assessed using the tool of ‘risk of bias’ according to Review Manager, version 5.2.5, software (RevMan; Cochrane Collaboration, Oxford, UK). Random number generation, allocation concealment, methods of blinding and incomplete and selective reporting were assessed based on the method of the trials. All the variables were graded ‘yes’, ‘no’ or ‘unclear’, which reflected a high risk of bias, low risk of bias and uncertain bias, respectively.

Statistical analysis

The primary outcome of the meta-analysis was visual analogue scale (VAS) score at different postoperative time points (4–8, 24 and 48 h) both at rest and during activity or coughing. The secondary outcomes were success rate of technique, postoperative opioid consumption and any other complications [hypotension, urinary retention, postoperative pulmonary complications (POPC)]. Where visual analogue pain scores were not reported on a 0 to 10 cm scale, the reported VAS scores were converted to a 10 cm scale for uniformity in analysis.

If the values were reported as median and an interquartile range or total range of values, the mean value was estimated using the median and the low and high ends of the range for samples smaller than 25; for samples greater than 25, the median itself was used. The mean and SD was estimated from the median and the low and high ends of the range for samples smaller than 15, as range/4 for samples from 15 to 70, and as range/6 for samples more than 70. If only an interquartile range was available, SD was estimated as interquartile range/1.35 as mentioned by Hayduk et al. If only an interquartile range was available, SD was estimated from the median and the low and high ends of the range for samples smaller than 25; for samples greater than 25, the median itself was used. The mean and SD was estimated from the median and the low and high ends of the range for samples smaller than 15, as range/4 for samples from 15 to 70, and as range/6 for samples more than 70. If only an interquartile range was available, SD was estimated as interquartile range/1.35 as mentioned by Hayduk et al. [11] and also used by Engelman and Marsala [12] in another meta-analysis.

In this meta-analysis, a summary statistic will be calculated for each study to describe the observed intervention effect, and a pooled intervention effect estimate is calculated as a weighted average of the intervention effects estimated in the individual studies.

We calculated the following:

(i) Pooled mean difference (MD) for the continuous variables using the inverse variance method. We calculated MD as we converted reported continuous variables in the same scale; hence, a standardized MD was not required. In this method, the standard deviations and sample size are used together to analyse the weight given to that study. RCTs with small standard deviations are given relatively higher weight, whereas the reverse is also true.

(ii) The pooled risk ratio (RR) for the dichotomous outcomes. We used RR, as it has consistency and is also easy to interpret, and the Mantel-Haenszel model, as it is more accurate than inverse variance methods where the number of the included studies is relatively small.

(iii) The risk reduction (i.e. [1 – relative risk] · 100), where a statistical significance will be found in any dichotomous outcomes for better clinical interpretation.

All statistical variables were calculated with 95% confidence interval (95% CI). The Q-test was used to analyse heterogeneity of included studies. When $I^2 < 40\%$, the inverse variance fixed model was used; otherwise, the random model was used for analysis, as $I^2$ value of 0–40% usually represents clinically unimportant heterogeneity.

Results

A total of 164 clinical studies were identified, and after exclusion of ineligible trials from perusal of the abstract, 17 clinical trials were identified. Kozar et al. [13] assessed only long-term post-thoracotomy pain (3 months) and was hence excluded from our analysis. We were not able to obtain the full text of two articles [14, 15], two were reporting on the cardiac surgical population [16, 17] and the remaining 12 trials [18–30] were finally included in the meta-analysis and systematic review, where PVB was compared with TEA after thoracotomy for lung surgery (Fig. 1). A brief protocol of the studies included for the meta-analysis has been summarized in Table 1. Summary of the results of these studies has been depicted in Table 2. The qualities of the studies have been depicted in Fig. 2 (risk of bias summary). Authors’ judgments about each risk of bias item presented as percentages across all included studies have been furnished in Supplementary Fig. 1. Publication bias was tested by the funnel plot and provided in Supplementary Fig. 2.

We contacted authors of three clinical trials for data that were not reported in a manner that enabled a quantitative analysis. However, none of them replied and we did a qualitative analysis where quantification was not possible. Results of the systematic review and meta-analysis have been summarized in the following subsections:

Technical considerations. Five studies [18, 23, 24, 26, 27] reported on percutaneous paravertebral catheter placement and the remainder [19–22, 25, 28–30] used surgically placed PVB catheters. Messina et al. [24] and Pintaric et al. [27] used levobupivacaine, while De Cosmo et al. [22], Casati et al. [23] and Kobayashi et al. [30] used ropivacaine in both epidural and PVB; all other authors used bupivacaine in either regional technique.

Postoperative pain control. We compared the reported VAS score at 4–8, 24 and 48 h after completion of thoracotomy both at rest and during activity/coughing. Pooled data analysis from the reported VAS scores delineated that VAS score at rest in the defined time points was similar in both the PVB and TEA groups (Fig. 3A–C). Quantitative analysis of VAS score during activity/coughing was possible in a smaller number of patients. The VAS score during activity was also found to be similar in both the groups at all measured time points (Fig. 4A–C). A summary of these findings has been furnished in Table 3.

We did a subgroup analysis of the VAS score at the above mentioned time points according to the method of PVB; whether
percutaneously or surgically placed. When VAS scores are tabulated according to the technique of paravertebral catheter insertion (percutaneous vs surgically placed), no differences were found for either technique when compared with TEA at all time points.

We also did a sensitivity analysis by considering studies that were not included in the meta-analysis by Davies et al. [9] and found that PVB provided a small but significant favourable VAS score at rest at the 48 h time point (MD 0.40 cm; 95% CI 0.77, 0.02; Mantel-Haenszel (M-H) fixed; Supplementary Fig. 3).

We were not able to analyse data from two clinical trials. Gulbahar et al. [25] did not report VAS scores at different time points; rather they mentioned that no significant differences were detected in postoperative days 1–3 between the two groups. Mukherjee et al. [26] did not use postoperative infusion and did not mention VAS scores. They reported a significantly prolonged duration of analgesia after single-injection PVB (MD 65.83 min; 95% CI 35.07, 96.59).

**Postoperative opioid consumption.** Pooled analysis reveals that patients who received PVB may require 14.26 mg (95% CI 3.71, 32.24) of morphine in the first 24 h of the postoperative period. Messina et al. [24] reported significantly more morphine consumption in patients receiving PVB in the 72 h postoperative period. However, Gulbahar et al. [25], Casati et al. [23], Pintaric et al. [27] and Grider et al. [29] reported similar postoperative opioid requirement in both the groups.

**Postoperative haemodynamics.** Pooled data analysis from eight trials shows that PVB is associated with significantly less hypotension than TEA (odds ratio [OR] 0.13; 95% CI 0.06, 0.31; M-H fixed) in both the intra- and postoperative period (Supplementary Fig. 4). Pintaric et al. [27] did not mention the number of patients who became hypotensive; rather they targeted oxygen delivery index (DO₂I) and stroke volume variation. They mentioned that patients in the TEA group required more colloid infusion and phenylephrine bolus dosage. They also reported that in the epidural group, systolic blood pressure was significantly lower at 24 and 48 h. Messina et al. [24] reported similar haemodynamic status of the patients in the postoperative period irrespective of analgesic technique. Mukherjee et al. [26] also reported that epidural analgesia may cause more hypotension than PVB.
Table 1: Summary of analgesic techniques

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients’ characteristics</th>
<th>Drug and dose</th>
<th>Level</th>
<th>Drug and dose</th>
<th>Level</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matthews and Govenden [18]</td>
<td>20 patients aged 45–70 years undergoing thoracotomy for lung resection</td>
<td>Bolus 10 ml of 0.25% bupivacaine, followed by 5 ml/h infusion, adjusted to 3–10 ml/h to achieve analgesia of T5–T12 dermatome</td>
<td>T5–T10 interspace</td>
<td>Bolus 10 ml of 0.25% bupivacaine, followed by 5 ml/h infusion, adjusted to 3–10 ml/h to achieve analgesia of T5–T12 dermatome</td>
<td>T5–T10 interspace</td>
<td>8 ml for 150–160 cm, 10 ml for 161–180 cm and 12 ml for &gt;180 cm</td>
</tr>
<tr>
<td>Perttunen et al. [19]</td>
<td>75 American Society of Anesthesiologist (ASA) I–III patients aged &gt;75 years undergoing elective antero-lateral thoracotomy for lung resection</td>
<td>Bolus of 0.25% bupivacaine according to the height of the patient, followed by infusion of 0.25% bupivacaine at a rate of 4, 6 and 8 ml/h</td>
<td>In the mid-clavicular line in second intercostal space</td>
<td>Bolus of 0.25% bupivacaine according to the height of the patient, followed by infusion of 0.25% bupivacaine at a rate of 4, 6 and 8 ml/h</td>
<td>T5–T10 interspace</td>
<td>Patients underwent oesophagectomy and antireflux procedures in addition to lung resection</td>
</tr>
<tr>
<td>Richardson et al. [20]</td>
<td>100 consecutive patients aged 17–80 years undergoing elective postero-lateral thoracotomy for a variety of procedures</td>
<td>Bolus 5 ml of 0.75% ropivacaine, a second bolus of 20 ml of 0.25% bupivacaine at the time of chest closure, followed by infusion of 0.5% bupivacaine 0.1 ml/kg/h</td>
<td>T6–T8 interspace</td>
<td>Test dose of 3 ml of 0.5% bupivacaine followed by 10–15 ml of 0.25% bupivacaine; a second bolus of 10 ml of 0.25% bupivacaine at the time of chest closure followed by infusion of 0.25% bupivacaine 0.1 ml/kg/h</td>
<td>T7–T10 interspace</td>
<td>The number of patients undergoing pneumonectomy by a postero-lateral incision was greater in patients receiving epidural analgesia</td>
</tr>
<tr>
<td>Bimston et al. [21]</td>
<td>50 patients, mean age of 65 years undergoing lung resection for malignant/infectious cause</td>
<td>Loading dose of 18 ml of 0.5% bupivacaine with epinephrine 1:200 000 and 2 ml fentanyl (100 µg). Infusion of fentanyl 10 µg/ml in bupivacaine 0.1% (10–15 ml/h initially, titrated down to 5–10 ml/h at 48 h)</td>
<td>Several interspaces below the thoracotomy incision</td>
<td>Loading dose of 18 ml of 0.5% bupivacaine with epinephrine 1:200 000 and 2 ml fentanyl (100 µg). Infusion of fentanyl 10 µg/ml in bupivacaine 0.1% (10–15 ml/h initially, titrated down to 5–10 ml/h at 48 h)</td>
<td>T5–T8 interspace</td>
<td>The number of patients undergoing pneumonectomy by a postero-lateral incision was greater in patients receiving epidural analgesia</td>
</tr>
<tr>
<td>De Cosmo et al. [22]</td>
<td>50 ASA I–III patients aged 20–75 years undergoing lung resection by a postero-lateral incision</td>
<td>20 ml of 0.475% ropivacaine bolus, followed by 0.3% ropivacaine infusion at 5 ml/h</td>
<td>T5–T8 interspace</td>
<td>3 ml of 0.2% ropivacaine, postoperative 0.2% ropivacaine with 0.75 µg/ml sufentanil infusion at 5 ml/h</td>
<td>T5–T8 interspace</td>
<td></td>
</tr>
<tr>
<td>Casati et al. [23]</td>
<td>42 ASA physical status I–III patients aged 32–77 years undergoing lobectomy via a postero-lateral incision</td>
<td>Loading dose of 18 ml of 0.5% ropivacaine divided into three injections at T4, T5 and T6; postoperative 0.2% ropivacaine infusion at the rate of 5 ml/h, titrating 2.5–10 ml/h targeting VAS &lt;4</td>
<td>Bolus 5 ml of 0.75% ropivacaine, postoperative 0.2% ropivacaine infusion at the rate of 5 ml/h, titrating 2.5–10 ml/h targeting VAS &lt;4</td>
<td>T5–T10 or T5–T7 interspace</td>
<td>T5–T10 interspace</td>
<td></td>
</tr>
<tr>
<td>Messina et al. [24]</td>
<td>24 ASA physical status (PS) II–III patients undergoing thoracotomy for lobectomy</td>
<td>0.25% levobupivacaine and fentanyl 1.6 µg/ml at the rate of 0.1 ml/kg/h</td>
<td>T5–T7 level</td>
<td>0.125% levobupivacaine with 2 µg/ml fentanyl at the rate of 0.08 ml/kg/h</td>
<td>T5–T7 level</td>
<td>Indication and type of thoracotomy not mentioned</td>
</tr>
<tr>
<td>Gulbahar et al. [25]</td>
<td>50 patients aged 13–73 years undergoing postero-lateral thoracotomy for any aetiology</td>
<td>Bupivacaine (5 ml of 0.25%) administered prior to thoracic closure at a rate of 0.10 ml/kg/h (1 h lock and 2 ml bolus) through a patient-controlled elastomeric infusion pump</td>
<td>In accordance with the thoracotomy space</td>
<td>Infusion of 0.25% of bupivacaine at a rate of 0.10 ml/kg/h (1 h lock and 2 ml bolus) through patient-controlled elastomeric infusion pump</td>
<td>T7–T10 interspace</td>
<td>The level of catheter insertion is different in two groups</td>
</tr>
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</table>
Table 1: (Continued)

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients’ characteristics</th>
<th>PVB Drug and dose</th>
<th>Level</th>
<th>TEA Drug and dose</th>
<th>Level</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mukherjee et al. [26]</td>
<td>60 patients aged 20-65 years undergoing postero-lateral thoracotomy for pulmonary and non-pulmonary pathology</td>
<td>Test dose: 3 ml of 2% lignocaine with 1:200 000 adrenaline, 15 ml of 0.25% bupivacaine and 50 µg fentanyl</td>
<td>T₅–T₆ interspace</td>
<td>Test dose: 3 ml of 2% lignocaine with 1:200 000 adrenaline 7.5 ml of 0.25% bupivacaine and 50 µg fentanyl</td>
<td>T₅–T₆ interspace</td>
<td>No postoperative infusion, study was stopped when patients asked for rescue analgesia</td>
</tr>
<tr>
<td>Pintaric et al. [27]</td>
<td>32 ASA physical status II and III patients, scheduled for elective antero-lateral thoracotomy</td>
<td>0.5% levobupivacaine and 30 µg/kg morphine</td>
<td>T₆–T₇ interspace</td>
<td>Test dose of 2 ml of lidocaine 2%, followed by a mixture of 0.25% levobupivacaine with 30 µg/kg morphine</td>
<td>T₆–T₇ interspace</td>
<td>Volume of 1 ml of local anaesthetic (LA) per segment/150 cm height and 0.1 ml of LA for each additional 5 cm: 10 segments required 10-fold volume. Infusion rate: 0.1 ml/kg/h, patient-controlled bolus of 0.1 ml/kg with the lockout interval of 60 min for 48 h</td>
</tr>
<tr>
<td>Kanazi et al. [28]</td>
<td>42 patients scheduled for elective postero-lateral thoracotomy for lung cancer</td>
<td>Bolus dose of 20 ml of 0.25% bupivacaine with 5 µg/ml of adrenaline and infusion of 0.125% bupivacaine 8 ml/h for 24 h postoperatively</td>
<td>Three intercostal level above the thoracotomy incision</td>
<td>Bolus dose of 10 ml of 0.125% bupivacaine with 5 µg/ml of adrenaline and infusion of 0.125% bupivacaine 8 ml/h for 24 h postoperatively</td>
<td>T₅–T₇ interspace</td>
<td>The infusion rate in both groups was increased in 2-ml increments (maximum of 12 ml/h) to maintain the visual analogue scale at rest (VAS₉) at &lt;7 cm. Patients were maintained on either TEA or subpleural analgesia as long as the VAS₉ was &lt;7 cm. If the VAS₉ score was 7 cm, the patient was transferred to the other analgesic technique and if either technique failed to achieve adequate pain relief (with VAS₉ at least 7 cm), patient controlled analgesia (PCA) was morphine started</td>
</tr>
<tr>
<td>Grider et al. [29]</td>
<td>75 ASA physical status I-III patients aged &lt;75 years scheduled for antero-lateral thoracotomy</td>
<td>Group PB (n = 25) = paravertebral infusions 0.25% bupivacaine at 8 ml/h</td>
<td>Surgically placed, under direct visualization, at the end of the procedure</td>
<td>Group EB (n = 25) = 0.25% bupivacaine Group EB + O (n = 25) = 0.25% bupivacaine with 0.01 mg/ml of hydromorphone Basal 2 ml/h with 1 ml every 10 min via PCA</td>
<td>T₆</td>
<td></td>
</tr>
<tr>
<td>Kobayashi et al. [30]</td>
<td>70 ASA I-II patients aged 20-75 years undergoing muscle sparing thoracotomy for lung resection</td>
<td>Group PVB (n = 35) = 2 ml of 1% lidocaine as a test dose. Ten millilitres of 0.375% ropivacaine were infused, followed by 84 ml of 0.2% ropivacaine and 800 µg of fentanyl at 5 ml/h</td>
<td>Surgically placed at the end of the procedure</td>
<td>Group EP (n = 35) = 0.2% ropivacaine bolus 5 ml, 84 ml of 0.2% ropivacaine and 800 µg fentanyl at 5 ml/h</td>
<td>T₄–T₇</td>
<td></td>
</tr>
</tbody>
</table>
Table 2: Summary of the findings of the studies

<table>
<thead>
<tr>
<th>Authors</th>
<th>Summary of findings of the studies</th>
<th>Other outcome</th>
<th>Complications</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matthews and Govenden [18]</td>
<td>Comparable analgesia in either technique up to 24 h postoperatively</td>
<td>Not mentioned</td>
<td>Hypotension and urine retention more frequent with TEA than with PVB</td>
<td>Adverse effects were comparable in either groups</td>
</tr>
<tr>
<td>Perttunen et al. [19]</td>
<td>Comparable analgesia in either technique at rest. TEA associated with more pain during coughing up to 4 h after surgery</td>
<td>Comparable postoperative morphine consumption</td>
<td>Pulmonary function and oximetry better in the PVB group. Glaucemic response was less in the PVB group</td>
<td>Hypotension was more common in the TEA group</td>
</tr>
<tr>
<td>Richardson et al. [20]</td>
<td>PVB provided better analgesia than TEA at rest and coughing</td>
<td>Cumulative morphine consumption was higher with TEA</td>
<td>Equivalent postoperative opioid consumption</td>
<td>Respiratory parameters were comparable</td>
</tr>
<tr>
<td>Brimston et al. [21]</td>
<td>TEA was more effective than PVB in the first 32 h, thereafter equally effective for postoperative analgesia</td>
<td>Equivalent postoperative ketorolac consumption</td>
<td>Respiratory parameters partial pressure of arterial oxygen/fraction of inspired oxygen concentration (PaO2/FiO2) are comparable in either group</td>
<td>More minor complications in the TEA group</td>
</tr>
<tr>
<td>De Cosmo et al. [22]</td>
<td>TEA provided superior analgesia up to 8 h postoperatively, then TEA and PVB were comparable</td>
<td>Respiratory parameters are comparable in either group</td>
<td>Ventilatory parameters were comparable</td>
<td>Patients’ satisfaction is greater in the PVB group</td>
</tr>
<tr>
<td>Casati et al. [23]</td>
<td>PVB and TEA are equally effective for postoperative analgesia, both at rest and coughing</td>
<td>Comparable number of patients required rescue morphine</td>
<td>Hypotension was more common in the TEA group</td>
<td></td>
</tr>
<tr>
<td>Messina et al. [24]</td>
<td>VAS at rest was comparable in either group</td>
<td>Morphine consumption was significantly higher in the PVB group</td>
<td>FVC was better preserved in the epidural group on Day 3</td>
<td></td>
</tr>
<tr>
<td>Gulbahar et al. [25]</td>
<td>PVB and TEA were equally effective for postoperative analgesia</td>
<td>Equivalent postoperative morphine consumption</td>
<td>Peak expiratory flow rate (PEFR), forced expiratory volume 1 (FEV1) and SpO2 was comparable in either group</td>
<td>More adverse effects with the TPB group</td>
</tr>
<tr>
<td>Mukherjee et al. [26]</td>
<td>Mean duration of postoperative analgesia after single bolus injection was longer in the TPB group</td>
<td>Not reported (NR)</td>
<td>NR</td>
<td>Hypotension was not observed in either group</td>
</tr>
<tr>
<td>Pintaric et al. [27]</td>
<td>Postoperative static and dynamic VAS scores were comparable in either group</td>
<td>Consumption of piritramide was similar in both groups</td>
<td>To maintain DO2I at or above the targeted value, a significantly higher amount of colloids was required in the TEA group</td>
<td>In the epidural group, systolic blood pressure was significantly lower at 24 and 48 h</td>
</tr>
<tr>
<td>Kanazi et al. [28]</td>
<td>TEA provided superior analgesia both at rest and coughing</td>
<td></td>
<td></td>
<td>Seven patients (33%) were converted to TEA at 3.9 (4.8) h because of an inability to maintain the VAS3 score of &lt;7 cm</td>
</tr>
<tr>
<td>Grider et al. [29]</td>
<td>Comparable analgesia with epidural LA and paravertebral LA; however, epidural LA + opioid provided superior pain relief</td>
<td>No difference in opioid use among patients using iv PCA supplementation</td>
<td>Postoperative spirometry was best with an epidural LA + opioid group</td>
<td></td>
</tr>
<tr>
<td>Kobayashi et al. [30]</td>
<td>PVB was not inferior to EP with respect to the primary endpoint: The mean VAS scores at rest, 2, 24 and 48 h after thoracotomy</td>
<td>No significant differences in the need for additional analgesic agents</td>
<td>Less time to insert catheter with PVB than EP</td>
<td>There were no significant differences between the groups in the incidence of complications</td>
</tr>
</tbody>
</table>
Postoperative respiratory parameters. The effects of PVB or TEA on postoperative parameters are controversial. Different authors studied different variables as markers of respiratory function, therefore a quantitative meta-analysis has not been possible. Perttunen et al. [19] reported similar changes in PaO₂ and forced expiratory volume 1 (FEV₁) in the postoperative period. Richardson et al. [20] measured peak expiratory flow rate (PEFR) as a marker of respiratory function. The lowest postoperative PEFR as a fraction of the preoperative control was 0.73 (SEM 0.06) in the paravertebral group in contrast to 0.54 (SEM 0.05) in the epidural group (P < 0.004). SpO₂ was also better in patients who received PVB. Bimston et al. [21] reported similar FEV₁ and FEV in the epidural and paravertebral group up to the 72 h postoperative period. Casati et al. [23] reported similar partial pressure of arterial oxygen/fraction of inspired oxygen concentration (PaO₂/FiO₂) values in the first 48 h postoperative period in both the PVB and TEA groups. However, Messina et al. [24] reported a significantly better preservation of forced vital capacity in the third postoperative day when epidural analgesia was used. Gulbahar et al. [25] reported a similar decline in PEFR and FEV₁ in the postoperative period across both the groups; SpO₂ was also no different in either group. Kanazi et al. [28] did not report any hypoxic episode in either group in the postoperative period.

Other reported complications. A pooled data analysis from five studies revealed that postoperative urinary retention may be less in patients receiving PVB (P = 0.0001; OR 0.18; 95% CI 0.07, 0.43; M-H fixed) in comparison with TEA.

Discussion

The most significant finding of our meta-analysis is an equivalent analgesic efficacy of PVB and TEA in thoracotomy patients. VAS scores measured both at rest and during activity at different time points in the postoperative period were equivalent with both of the analgesic techniques. The technique of paravertebral catheter insertion, either percutaneously or surgical, does not influence the analgesic efficacy. Considering studies conducted after 2006, a small but statistically favourable VAS score at rest at 48 h has been found. No difference in the postoperative opioid consumption has been found. However, PVB is associated with significantly less hypotension and urinary retention.

We have found that PVB provides similar pain relief after thoracotomy for lung surgery in comparison with TEA. However, it is not possible to comment on the effect of either analgesic technique on postoperative opioid consumption. Previous meta-analysis by Davies et al. [9] reported similar findings. However, they did not include a lung surgery population and extra-pleural intercostal analgesic technique. Scarci et al. [10], in a systematic review, concluded that PVB is at least as effective as epidural analgesia and has a better side-effect profile with a lower complication rate than epidural analgesia. However, in most of the studies, epidural catheter placement was not congruent with the site of thoracotomy incision. Again, pain during coughing or deep breathing may be a more significant parameter for analgesic efficacy [31], particularly after thoracotomy, but only four trials specifically addressed this issue. A recent randomized controlled trial compared the efficacy of combined intrathecal morphine and PVB with that of TEA. It found a small but statistically favourable VAS score in patients receiving TEA. Richardson et al. [20] found that PVB provided superior analgesia to TEA; however they placed the epidural catheter in the T₇–T₁₀ intervertebral space, which may be too low for thoracotomy. A paravertebral catheter may be placed either percutaneously or surgically; no data demonstrated the superiority of any technique. We included studies irrespective of the technique used for PVB, and a subgroup analysis failed to show any difference in efficacy. However, we may conclude that the success rate of PVB has increased over time as operators have gained more experience, and this has been reflected as a favourable VAS score among the newer studies at least at one point of time. Nowadays, ultrasound is increasing being used in PVB to make it safer with increased efficacy.

Some of the studies included in this analysis used thoracic epidural anaesthesia with local anaesthetic only, whereas a combination of local anaesthetic and opioid can provide superior analgesia to local anaesthetic alone [9]. The addition of a small dosage of epinephrine with opioid and local anaesthetic in thoracic epidural anaesthesia has been found to provide superior analgesia with a better side-effect profile [31, 32]; however, none of these studies used such regimens. Apart from that, most of the studies used a higher concentration of local anaesthetic in PVB than in thoracic epidural block. So, it is impossible to decide whether with equal concentration of local anaesthetic, TEA and PVB are equally effective or not. With the use of higher
concentration and/or volume of local anaesthetic, hypotension, urinary retention and even bilateral block may be increased with PVB. We are unable to comment with certainty whether a lower concentration of local anaesthetic in PVB would be equally effective or not. It is worth mentioning here that Mukherjee et al. [26] used a similar concentration of local anaesthetic in both the techniques and noted a significantly prolonged duration of analgesia in patients receiving PVB after a single bolus dosing.

Two studies reported postoperative opioid consumption as a marker of analgesic efficacy. However, when a lipophilic opioid such as fentanyl is used, systemic absorption also contributes to the analgesic action; hence, it is difficult to draw a definite conclusion here.

On the other hand, epidural anaesthesia may be associated with some serious concerns such as epidural haematoma, epidural abscess and nerve injury. The use of PVB may avert these potentially devastating complications.

Whether PVB is associated with fewer complications or not may be debatable, but PVB causes significantly less hypotension, most probably due to a unilateral segmental block. However, again the comparison of haemodynamic data should be interpreted with caution as the concentration and volume of local anaesthetic were not similar across the studies, and, in some cases, regional block was used along with general anaesthesia, which may aggravate hypotension. Methods of haemodynamic data collection, such as invasive vs non-invasive blood pressure measurement or systolic vs diastolic vs mean arterial pressure measurement, may also influence outcome. Pre-existing comorbid conditions such as congestive heart failure, ischaemic heart disease, etc. can also influence intraoperative haemodynamics and may be a potential source of bias. Although a quantitative analysis was not possible, probably there is no clinically significant difference in postoperative ventilatory and oxygenation parameters between the groups. Our analysis differs from the previous meta-analysis by Davies et al. [9] in a number of ways. First, we have not included ‘extra-pleural intercostal’ analgesic technique in this analysis. Recent evidence suggest that PVB may be a different approach for epidural analgesia only [32]. On the contrary, extra-pleural analgesia is aimed at blocking targeted intercostal nerves only [33, 34]. Moreover, there is clinical evidence that intercostal analgesia has no effect on post-thoracotomy pain relief in addition to epidural analgesia [35]. Thus, we did not find logical reason to include ‘extra-pleural analgesia’ as a type of PVB. Secondly, we included studies where thoracotomy was done only for lung surgery and excluded cardiac surgical cases. Thirdly, where a quantitative analysis has not been possible, a narrative review of the available data has been included. We have included seven new clinical trials [23–25, 27–30] for analysis and one clinical trial [26] for qualitative analysis in this review that have been published since the previous analysis.
None of the included studies mentioned the technical failures of the regional technique. It is well known that PVB may have a high failure rate and it may even be higher with percutaneous catheter placement. Although, in a subgroup analysis, we found that the technique of paravertebral catheter insertion has no effect on the analgesic efficacy, none of the RCTs explicitly mentioned the incidence of failed PVB technique.

Limitations

Despite extensive electronic search in many databases, we were able to include only 494 patients for this meta-analysis. All the included studies were individually small and some studies did not reveal the methods of randomization. Data reporting among the included studies varied significantly and we were not able to include most of the studies for quantitative analysis. The techniques of both epidural and paravertebral analgesia were different across the studies. Therefore, at times, it was very difficult to interpret the reported results from all these studies. There are some methodological issues with some studies, e.g. Mukherjee et al. [26] did use a postoperative infusion, and only evaluated the duration of analgesia after a single injection. Kanazi et al. [28] targeted a VAS of <7, and this level of pain may be unacceptable. We only included RCTs published in the English language; hence, inclusion of studies published in other languages may influence the final result.

Conclusion

Thoracic PVB may be as effective as TEA for managing post-thoracotomy pain after lung surgery and safer also; however, a higher concentration of local anaesthetic is required in PVB than in epidural analgesia to achieve an optimum level of analgesia.
SUPPLEMENTARY MATERIAL

Supplementary material is available at /CVTS online.

Conflict of interest: none declared.

REFERENCES


eComment. Epidural analgesia versus paravertebral analgesia technique

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I read with great interest the systematic review and meta-analysis by Baidya et al. in which they compared efficacy of two different strategies for pain control in patients undergoing thoracotomy [1]. After including 12 clinical trials in their analysis, they concluded that there is an equivalent analgesic efficacy of epidural anaesthesia and paravertebral anaesthesia. Recently, the results of an additional randomized study