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REVIEW ARTICLE

A comparison of the analgesic efficacy and side-effects of paravertebral *vs* epidural blockade for thoracotomy—a systematic review and meta-analysis of randomized trials

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Epidural analgesia is considered by many to be the best method of pain relief after major surgery. It is used routinely in many thoracic surgery centres. Although effective, side-effects include hypotension, urinary retention, incomplete (or failed) block, and, in rare cases, paraplegia. Paravertebral block (PVB) is an alternative technique that may offer comparable analgesic effectiveness and a better side-effect profile. We undertook a systematic review and meta-analysis of all relevant randomized trials comparing PVB with epidural analgesia in thoracic surgery. Data were abstracted and verified by both authors. Studies were tested for heterogeneity, and meta-analyses were done with random effects or fixed effects models. Weighted mean difference (WMD) was used for numerical outcomes and odds ratio (OR) for dichotomous outcomes, both with 95% CI.

We identified 10 trials that had enrolled 520 thoracic surgery patients. All of the trials were small (n<130) and none were blinded. There was no significant difference between PVB and epidural groups for pain scores at 4–8, 24 or 48 h, WMD 0.37 (95% CI: −0.5, 121), 0.05 (−0.6, 0.7), −0.04 (−0.4, 0.3), respectively. Pulmonary complications occurred less often with PVB, OR 0.36 (0.14, 0.92). Urinary retention, OR 0.23 (0.10, 0.51), nausea and vomiting, OR 0.47 (0.24, 0.53), and hypotension, OR 0.23 (0.11, 0.48), were less common with PVB. Rates of failed block were lower in the PVB group, OR 0.28 (0.2, 0.6). PVB and epidural analgesia provide comparable pain relief after thoracic surgery, but PVB has a better side-effect profile and is associated with a reduction in pulmonary complications. PVB can be recommended for major thoracic surgery.

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Thoracotomy and upper abdominal surgery are associated with severe postoperative pain and marked impairment of respiratory function.[21 31 40] Postoperative analgesia regimens often include a regional anaesthetic technique because complete analgesia with a single agent or method may not be possible.[13] Epidural analgesia with local anaesthetic, opioid, or both has become commonplace and has been regarded as the 'gold standard'.[48] A survey of analgesic techniques, after thoracotomy, in Australian hospitals showed that 79% of respondents regarded epidural blockade as the best available technique.[6] A similar survey of UK practice, after upper abdominal surgery, found that 80% of anaesthetists considered epidural analgesia to be the best mode of pain relief.[5] Epidural blockade has been shown to reduce the intraoperative surgical stress response and has possible advantages for cardiovascular, respiratory, coagulation, gastrointestinal, metabolic and immune function.[25 39] However, thoracic epidurals can cause hypotension, neurological injury,[15] and are contra-indicated in the presence of coagulopathy or local sepsis.

Thoracic paravertebral block (PVB) has enjoyed a resurgence in recent years.[36] The paravertebral space is a wedge-shaped space that lies to the side of the vertebral column and contains the spinal (intercostal) nerve, the dorsal ramus, the rami communicantes and the sympathetic chain.[29] Placement of local anaesthetic within the paravertebral space produces unilateral somatic and sympathetic block, which is advantageous for unilateral surgical procedures of the chest and abdomen.[19]

The classic technique described for PVB is a posterior approach using loss of resistance to air or saline as the superior costotransverse ligament is traversed.[11] Recent modifications to this technique have utilized a nerve stimulator.[23 47] Alternatively, catheters can be placed in the paravertebral space intraoperatively under direct vision by the surgeon before chest closure.[1 42]

The literature can be confusing, as the technique has been described by several different terms: PVB; continuous intercostal nerve block; extrapleural intercostal nerve block; extrapleural PVB; and retropleural analgesia.[20] However, it has been demonstrated radiologically, that the site of action of local anaesthetic via an extrapleural intercostal catheter is primarily via the paravertebral space.[14]

Proponents of PVB claim it is simple, safe, easy to learn, and with a low incidence of complications.[19 26 32 43] The safety of paravertebral infusions allows management of these patients on the surgical wards, often avoiding the need for high dependency or intensive care beds that may be felt necessary for patients with thoracic epidurals.[4 44] Paravertebral blockade is an appealing option in patients in whom epidural analgesia may be contra-indicated (local sepsis, coagulopathy, pre-existing neurological disease and difficult thoracic spine anatomy). Many studies have shown thoracic PVB to be an effective form of analgesia after thoracotomy, multiple fractured ribs, major breast surgery and inguinal hernia repair.[19 41]

A narrative review of pain control techniques after thoracic surgery concluded that it was impossible to determine from the available literature whether paravertebral blockade is useful for postoperative analgesia after thoracotomy.[21] A recent editorial in this journal concluded that the best methods of pain relief after thoracotomy would have to be sought from evidence-based anaesthesia.[45] We therefore performed a meta-analysis of randomized trials comparing thoracic PVB with epidural analgesia, to evaluate efficacy and safety.

Methods

A systematic review of relevant randomized trials comparing PVB with epidural analgesia for postoperative pain relief was undertaken. The MEDLINE and EMBASE databases and the Cochrane Central Register of Controlled Trials were searched by two of the authors using the following combinations of search terms: paravertebral, extrapleural intercostal, continuous intercostal, epidural, extradural, and peridural. No language restrictions were applied. The papers were retrieved to identify relevant studies for inclusion in the meta-analysis. The reference lists of these papers were scrutinized to identify further relevant studies. In addition, we contacted some known researchers in the field. Reports were included if the study was a randomized trial comparing PVB with thoracic epidural analgesia in thoracic surgery, and including administration of a local anaesthetic agent. Lumbar epidural block and epidural opioid-only regimens were excluded. All methods of insertion of PVB (whether before operation by the anaesthetist or intraoperatively by the surgeon) were included.

All studies were examined to identify parameters that could be compared between papers. Data from the studies were independently checked by two of the authors (R.G.D. and P.S.M.). If data were not available from the original publication, the authors were contacted via email to request this information.

We were able to compare the following variables between studies: pain scores at 4–8 h,[2 3 8 10 24 30 35 38] 24 h,[3 8 18 24 30 35 38 46] 48 h;[3 8 18 24 35 38 46] mean dose of opioids at 24 and 48 h;[18 24 35 38 46] number of patients requiring supplemental analgesia;[2 3 10 24] technique failure;[2 10 18 24 35 38] respiratory function at 24 and 48 h;[3 8 18 24 35 38 46] urinary retention;[2 8 18 24 30 35] nausea and vomiting;[3 8 10 24 35 38] hypotension;[3 10 24 30 38] respiratory depression;[3 10 24 35 38] pulmonary complications;[3 18 24 38] and length of hospital stay.[3 8 18 24 35 38] The primary endpoint for efficacy was avoidance of pulmonary complications, and for safety was hypotension.

An intention-to-treat analysis was performed, based on the original data. In order to include as many studies as possible for pain scores during the 4–8 h period, the worst mean pain score during this time was used. Where pain scores were given for pain at rest and on movement, the worst pain score for that time period was used. Where visual analogue pain scores were not measured on a 0–10 scale (0–4 in reference 17, 0–50 cm in reference 34), the numbers were converted to a 10 cm scale. One study[18] used nicomorphine for supplemental analgesia, which is considered to be equipotent to morphine and therefore a direct comparison with morphine was made for the amount of opioid consumed.[22] Meperidine was used as supplemental analgesia in one study[46] and therefore equivalent morphine consumption was estimated from the potency ratio of morphine to meperidine of 1:10. Respiratory function was recorded as the % change from the preoperative value of either the forced expiratory volume in 1 s or peak expiratory flow rate. Pulmonary complications were identified where clinical evidence of pneumonia or atelectasis existed. Where separate data for nausea and vomiting was given, we used only the data for vomiting assuming that all patients who were vomiting were also suffering from nausea. When no SD was given for continuous data, the SD was imputed with the *t*-test if the *P* value was stated, otherwise the SD was estimated as half of the mean value. When data were presented as 95% CI, the SD was calculated from a standard formula for a normal distribution ($\mathrm{SD}=95\%\ \mathrm{CI}/1.96\times\sqrt{n}$). When the median and range were reported for continuous outcomes, the mean and SD were estimated by assuming that the mean was equivalent to the median and that the SD was one quarter of the range.[34]

The quality (validity) of individual trials was quantified by the Jadad scale,[17] using five criteria (one point each): (i) proper randomization, (ii) double blind, (iii) withdrawals documented, (iv) randomization adequately described, (v) blindness adequately described.

Meta-analysis was performed using Review Manager (RevMan for Windows version 4.2.2, The Cochrane Collaboration, Oxford, UK). The weighted mean difference (WMD) was calculated for numerical data and odds ratio (OR) was calculated for dichotomous data, both with 95% CI. If heterogeneity was significant ($P \leq 0.05$) then a random effects model was used and if heterogeneity was non-significant ($P>0.05$), a fixed effects model was used. Heterogeneity was analysed using the I^2 and Q statistics.[16] All tests of statistical significance were two-sided.

Results

Our literature search identified 14 studies that were potentially relevant. Three studies were excluded because they used lumbar epidural morphine,[7 33 37] and one was not randomized.[27] One study included patients scheduled for open cholecystectomy and was therefore excluded.[2] One study was excluded because the method of catheter insertion was inadequately described and too different from the continuous extrapleural intercostal nerve catheter insertions of other studies to conclude that the effect was paravertebral.[9] Ten studies were included in the final meta-analysis.[3 8 10 18 24 28 30 35 38 46] These studies were published between 1989 and 2005 and included 520 adult patients. The characteristics of the study populations are summarized in Table 1. All the studies were of moderate quality, largely because none were blinded and so the maximum possible Jadad score was 3.

We found a significant reduction in the rate of pulmonary complications with PVB when compared with epidural analgesia, OR 0.36 (0.14, 0.92) (Fig. 1). PVB was associated with a reduction in urinary retention, postoperative nausea and vomiting, and hypotension, OR 0.23 (0.10, 0.51), 0.47 (0.24, 0.93), 0.12 (0.04, 0.36) respectively (Fig. 2). There was no difference in the rates of respiratory depression between the two groups, OR 1.54 (0.61, 3.92).

There was no statistically significant difference in pain scores between PVB and epidural groups at 4–8, 24 or 48 h, WMD 0.37 (−0.5, 1.2), 0.05 (−0.6, 0.7), −0.04 (−0.4, 0.3) (Fig. 3). There was no statistically significant difference in morphine consumption between PVB and epidural groups at 24 h or 24–48 h, WMD 5.9 mg (−18.3, 6.6), −1.9 mg (−8.8, 4.4) respectively (Fig. 4). There was no statistically

Table 1 Characteristics of the randomized trials included in the meta-analysis. *Each study is rated according to its quality of bias-minimization using the Jadad scale,[17] 0 (high bias) to 5 (low bias). PCA, patient controlled analgesia; PO, per oral; SC, subcutaneous; PR, per rectal

Study*	Type of surgery	No. of patients	Epidural block	PVB	Additional analgesics
Matthews *et al.*[30] (Jadad score 3)	Thoracotomy	20	Thoracic bupivacaine 0.25% bolus, then infusion	Catheter inserted post-induction; bupivacaine 0.25% bolus+infusion	None
Richardson *et al.*[38] (Jadad score 3)	Thoracotomy	36	Thoracic bupivacaine 0.25% bolus, then infusion	Catheter inserted by surgeon; bupivacaine 0.25% bolus+infusion	PCA morphine
Dhole *et al.*[10] (Jadad score 2)	Thoracotomy	30	Thoracic bupivacaine 0.5% intraoperatively, then 0.25–0.375% bupivacaine+fentanyl infusion	Catheter inserted by surgeon; bupivacaine 0.5% bolus+infusion	PO meflumenaminic acid SC nicomorphine
De Cosmo *et al.*[8] (Jadad score 2)	Thoracotomy	100	Thoracic bupivacaine 0.25% bolus, then infusion	Single injection pre-induction, then intraoperative catheter placement by surgeon; pre-induction bupivacaine 0.5% bolus; intraoperative bupivacaine 0.25% bolus; postoperative bupivacaine 0.5% infusion	PO/PR diclofenac PCA morphine
Wedad *et al.*[46] (Jadad score 2)	Thoracotomy	50	Thoracic bupivacaine 0.1%+fentanyl infusion	Catheter inserted by surgeon; bupivacaine 0.5%+fentanyl bolus; bupivacaine 0.1%+fentanyl infusion	Not specified
Luketich *et al.*[28] (Jadad score 2)	Thoracotomy	41	Thoracic bupivacaine 0.5% bolus, then bupivacaine 0.25% infusion	Catheter inserted pre-induction; bupivacaine 0.5% bolus; bupivacaine 0.25% infusion	i.m. ketorolac
Leaver *et al.*[24] (Jadad score 3)	Thoracotomy	50	Thoracic ropivacaine 0.2%+sufentanil bolus, then infusion	Catheter inserted by surgeon; ropivacaine 0.475% bolus; ropivacaine 0.3% infusion	i.v. ketorolac
Pertunnen *et al.*[35] (Jadad score 2)	Thoracotomy	40	Thoracic bupivacaine 0.25% bolus, then infusion	Catheter inserted by surgeon; bupivacaine 0.25% bolus+infusion	Meperidine
Kaiser *et al.*[17] (Jadad score 2)	Thoracotomy	124	Thoracic bupivacaine 0.125%+morphine infusion	Percutaneous nerve block pre-induction, then intraoperative catheter placement by surgeon; pre-induction bupivacaine 0.25% bolus; intraoperative bupivacaine 0.5% bolus; postoperative bupivacaine 0.25% infusion	PCA morphine
Richardson *et al.*[38] (Jadad score 3)	Thoracotomy	29	Thoracic bupivacaine 0.5% bolus, then bupivacaine 0.125% infusion	Catheter inserted by surgeon; 0.5% bupivacaine bolus + infusion	PCA morphine

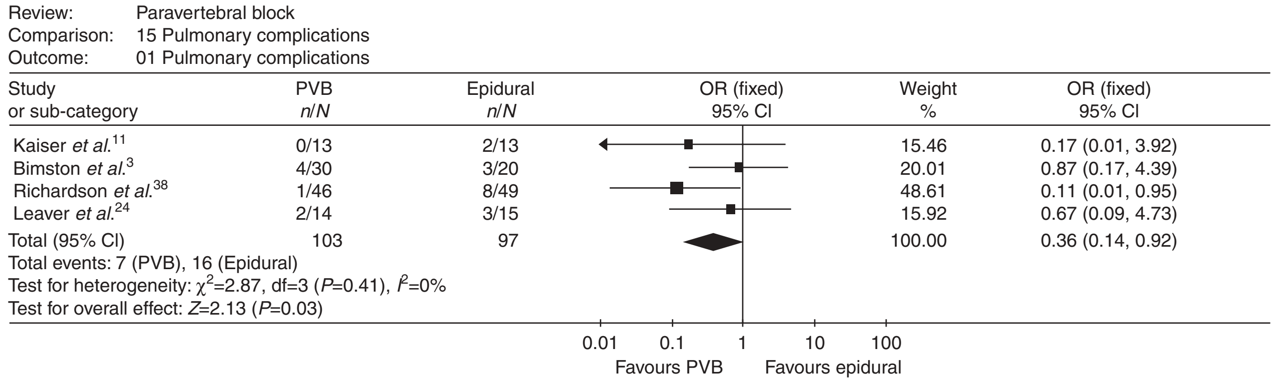


Fig 1 A meta-analysis of trials comparing PVB with epidural analgesia on postoperative pulmonary complications.

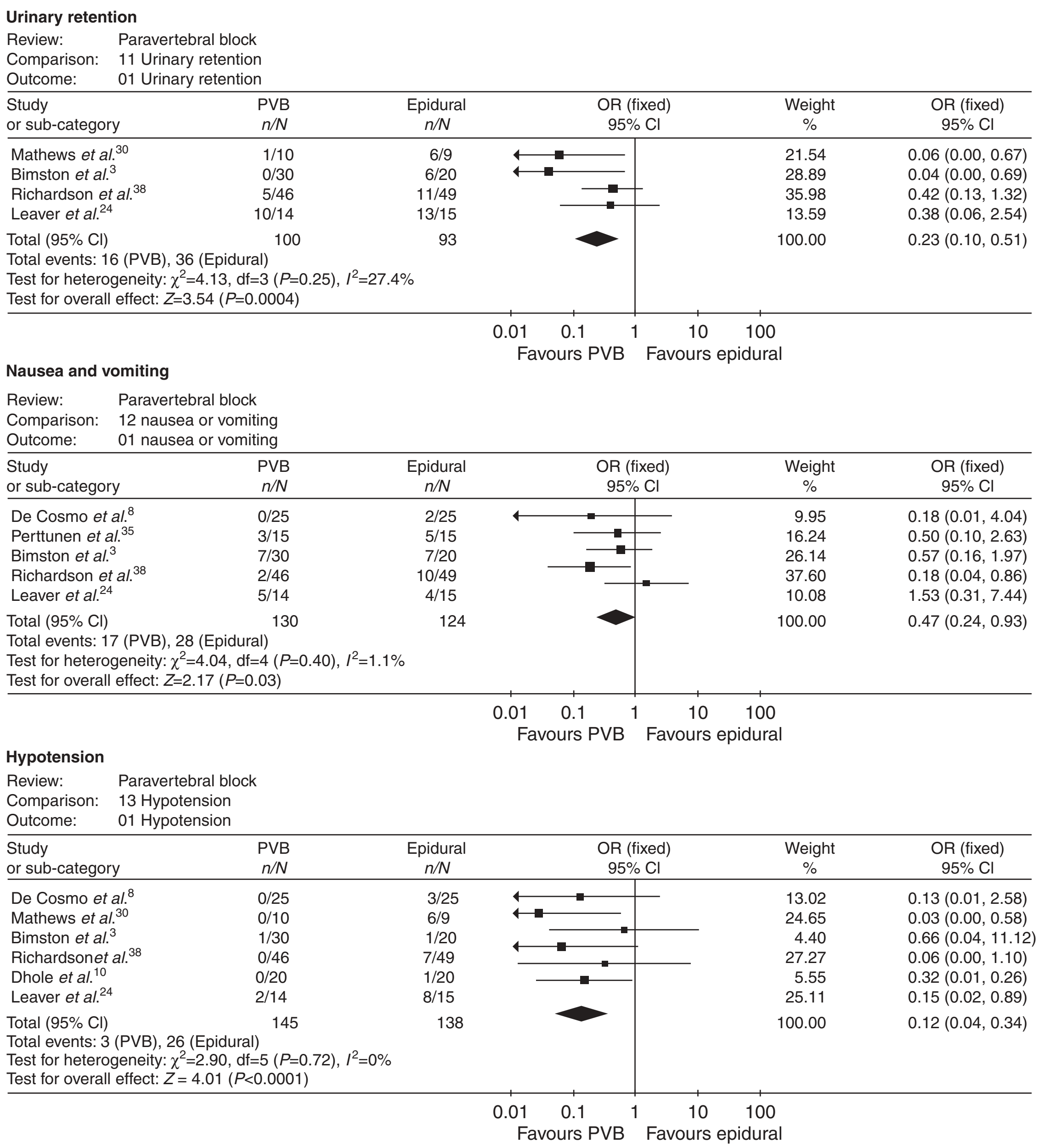


Fig 2 A meta-analysis of trials comparing PVB with epidural analgesia on side-effects associated with analgesic therapy.

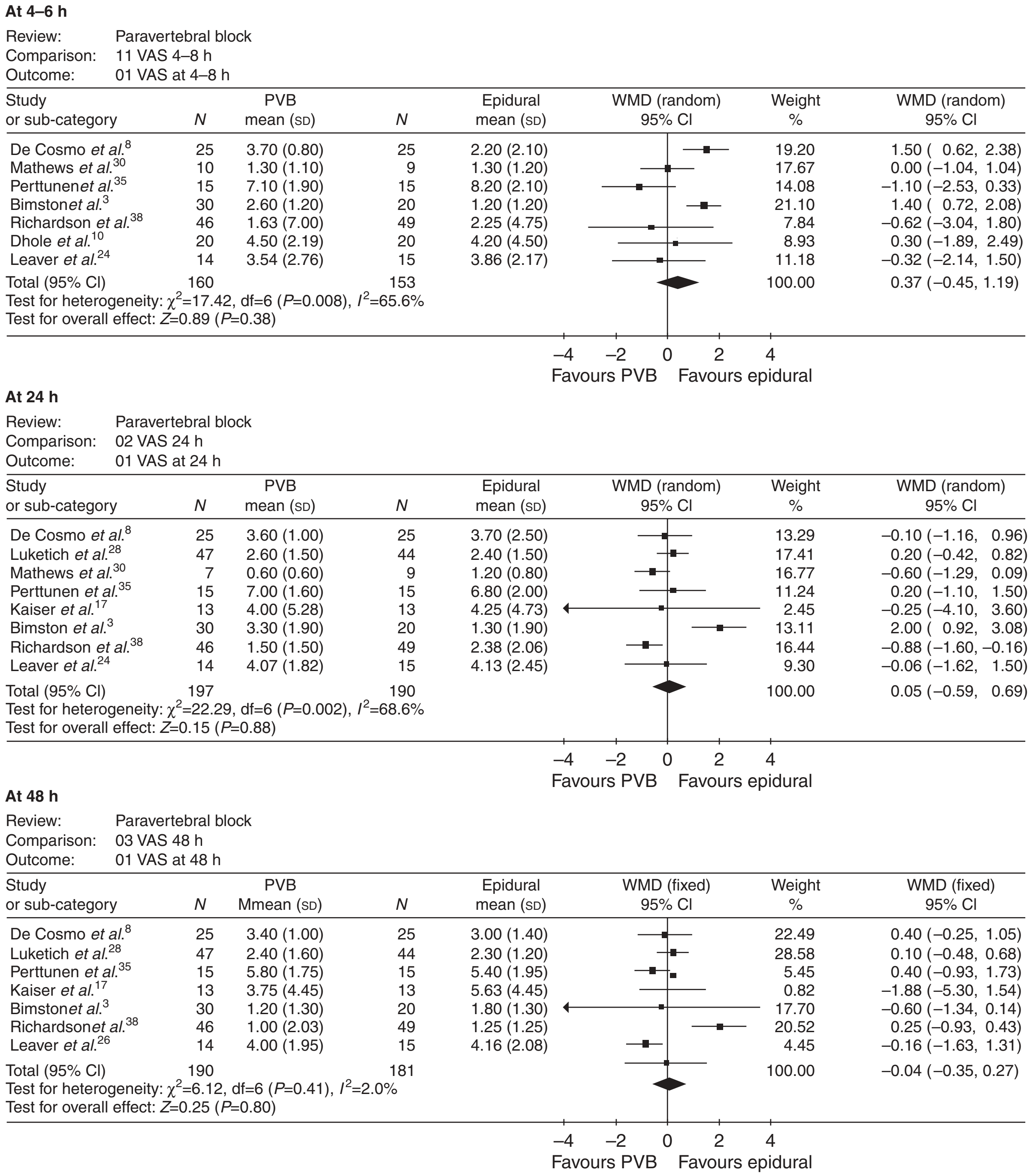


Fig 3 A meta-analysis of trials comparing PVB with epidural analgesia on pain visual analogue scale scores.

significant difference in the use of supplemental analgesia between the PVB and epidural groups, OR 0.63 (0.31, 1.31). Rates of failed technique were lower in the PVB group, OR 0.28 (0.2, 0.6), P=0.007 (Fig. 5).

Respiratory function was improved at both 24 and 48 h with PVB but only significantly improved at 24 h, WMD 6% (3, 9), 8% (−1, 17) respectively (Fig. 6). There was no significant difference in the length of hospital stay, WMD −0.2 days (−0.9, 0.5).

Discussion

This meta-analysis of 10 randomized trials demonstrates that PVB provides comparable analgesia with epidural blockade after surgery but has a better side-effect profile. PVB is associated with less urinary retention, less postoperative nausea and vomiting, less hypotension and a reduction in pulmonary complications.

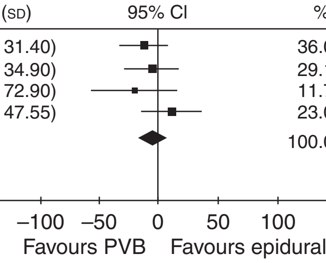
Effective postoperative analgesia is believed to reduce morbidity, quicken recovery, improve patient outcome

At 24 h

Review: Paravertebral block
Comparison: 04 morphine 24 h
Outcome: 01 morphine usage up to 24 h

Study or sub-category	N	PVB mean (SD)	N	Epidural mean (SD)	WMD (random) 95% CI	Weight %	WMD (fixed) 95% CI
Perttunen *et al.*[35]	15	68.20 (26.20)	15	80.50 (31.40)		36.07	–12.30 (–33.00, 8.40)
Kaiser *et al.*[17]	13	15.30 (24.00)	13	21.00 (34.90)		29.14	–5.70 (–28.72, 17.32)
Richardson *et al.*[38]	46	85.50 (103.80)	49	105.80 (72.90)		11.73	–20.30 (–56.58, 15.98)
Leaver *et al.*[24]	14	43.60 (18.20)	15	32.20 (47.55)		23.06	11.40 (–14.48, 37.28)
Total	88		92			100.00	–5.85 (–18.28, 6.58)

Test for heterogeneity: χ^2=2.69, df=3 (*P*=0.44), I^2=0%
Test for overall effect: *Z*=0.92 (*P*=0.36)



At 48 h

Review: Paravertebral block
Comparison: 05 morphine 48 h
Outcome: 01 morphine usage 24-48 h

Study or sub-category	N	PVB man (SD)	N	Epidural mean (SD)	WMD (random) 95% CI	Weight %	WMD (fixed) 95% CI
Wedad *et al.*[46]	20	36.00 (1.50)	20	36.70 (1.60)		77.23	–0.70 (–1.66, 0.26)
Perttunen *et al.*[35]	15	30.00 (41.90)	15	42.20 (52.30)		3.27	–12.20 (–46.11, 21.71)
Kaiser *et al.*[17]	13	12.00 (22.80)	13	26.70 (26.40)		9.57	–14.70 (–33.66, 4.26)
Richardson *et al.*[38]	46	125.20 (116.90)	49	156.20 (166.40)		1.17	–31.00 (–88.55, 26.55)
Leaver *et al.*[24]	14	32.00 (23.44)	15	22.30 (31.05)		8.76	9.70 (–10.24, 29.64)
Total (95% CI)	108		112			100.00	–1.86 (–8.12, 4.40)

Test for heterogeneity: χ^2=4.64, df=4 (*P*=0.33), I^2=13.8%
Test for overall effect: *Z*=0.58 (*P*=0.56)

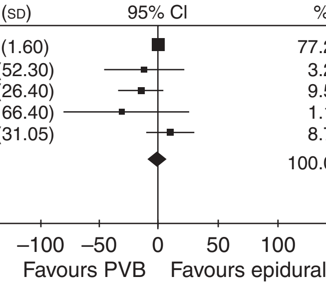


Fig 4 A meta-analysis of trials comparing PVB with epidural analgesia on morphine consumption after surgery.

Review: Paravertebral block
Comparison: 07 failed technique
Outcome: 01 Inadequate block

Study or sub-category	PVB n/N	Epidural n/N	OR (fixed) 95% CI	Weight %	OR (fixed) 95% CI
Luketich *et al.*[28]	4/47	9/44		34.86	0.36 (0.10, 1.27)
Perttunen *et al.*[35]	0/17	2/19		9.44	0.20 (0.01, 4.47)
Kaiser *et al.*[17]	2/15	2/15		7.10	1.00 (0.12, 8.21)
Richardson *et al.*[38]	0/46	5/54		20.55	0.10 (0.01, 1.80)
Dhole*et al.*[10]	0/20	1/20		6.00	0.32 (0.01, 8.26)
Leaver*et al.*[24]	1/14	6/15		22.05	0.12 (0.02, 1.13)
Total (95% CI)	159	167		100.00	0.28 (0.12, 0.64)

Total events: 7 (PVB), 25 (Epidural)
Test for heterogeneity: χ^2=2.70, df=5 (*P*=0.75), I^2=0%
Test for overall effect: *Z*=3.04 (*P*=0.002)

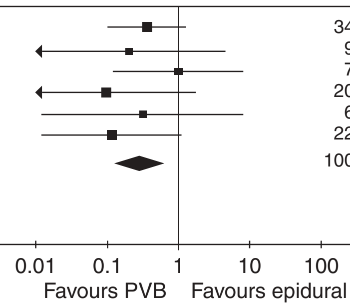


Fig 5 A meta-analysis of trials comparing PVB with epidural analgesia on regional block failure.

and reduce hospital costs. Thoracic epidural analgesia is commonly used after thoracotomy and upper abdominal surgery. However, there are risks associated with the technique such as dural puncture, neurological injury and paraplegia. Management of epidural analgesia on the wards may not always be appropriate in some institutions, necessitating the use of high dependency or intensive care beds for these patients. Occasionally, the epidural technique fails as a result of difficult anatomy or poor technique and is contra-indicated in sepsis, coagulation disorders, pre-existing neurological disorders, and difficult thoracic vertebral anatomy. In these situations, PVB offers an attractive alternative that has few contraindications.[18 35] Placement of the paravertebral catheter intraoperatively by the surgeon during thoracotomy further avoids some of the concerns regarding epidural placement in the presence of difficult anatomy, local sepsis or impaired coagulation. Although our meta-analysis has shown there was no difference in pain scores between PVB and epidural analgesia, there was a statistically significant reduction in complications with PVB.

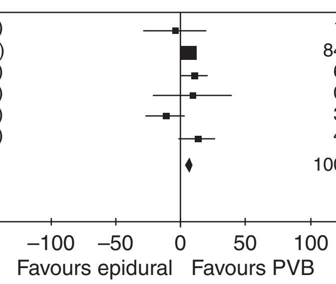
The insertion methods for the PVB in the studies in this meta-analysis varied. In some studies, the PVB was inserted before operation (pre-emptive) whereas in other studies, the

At 24 h

Review: Paravertebral block
Comparison: 08 Respiratory function 24 h
Outcome: 01 Respiratory function at 24 h

Study or sub-category	*N*	PVB mean (SD)	*N*	Epidural mean (SD)	Weight %	WMD (fixed) 95% CI
De Cosmo *et al.*[8]	25	54.00 (38.00)	25	58.00 (50.00)	1.33	−4.00 (−28.62, 20.62)
Wedad *et al.*[46]	20	60.00 (5.00)	20	54.00 (5.00)	84.06	6.00 (2.90, 9.10)
Perttunen *et al.*[35]	15	71.00 (12.90)	15	60.00 (18.10)	6.38	10.40 (−0.85, 21.65)
Kaiser *et al.*[17]	13	50.50 (47.30)	13	41.20 (31.50)	0.85	9.30 (−21.59, 40.19)
Bimston *et al.*[3]	30	47.60 (23.80)	20	59.30 (29.65)	3.34	−11.70 (−27.24, 3.84)
Richardson *et al.*[38]	46	85.00 (34.60)	49	72.00 (35.70)	4.04	13.00 (−1.14, 27.14)
Total (95% CI)	149		142		100.00	5.87 (3.02, 8.71)

Test for heterogeneity: χ^2=7.18, df = 5 (P=0.21), I^2 = 30.4%
Test for overall effect: Z=4.05 (P=0.0001)



At 48 h

Review: Paravertebral block
Comparison: 09 Respiratory function 48 h
Outcome: 01 Respiratory function at 48 h

Study or sub-category	*N*	PVB mean (SD)	*N*	Epidural mean (SD)	Weight %	WMD (random) 95% CI
De Cosmo *et al.*[8]	25	65.00 (50.00)	25	64.00 (50.00)	7.02	1.00 (−26.72, 28.72)
Luketich *et al.*[28]	47	37.00 (7.50)	44	41.00 (13.00)	21.27	−4.00 (−8.40, 0.40)
Wedad *et al.*[46]	20	69.00 (5.00)	20	57.00 (5.00)	21.85	12.00 (8.90, 15.10)
Perttunen *et al.*[35]	15	62.60 (10.30)	15	53.50 (19.10)	16.69	9.10 (−1.88, 20.08)
Kaiser *et al.*[17]	13	51.10 (40.60)	13	34.50 (22.50)	7.96	16.60 (−8.63, 41.83)
Bimston *et al.*[3]	30	57.70 (29.00)	20	56.00 (28.00)	12.91	1.70 (−14.37, 17.77)
Richardon *et al.*[38]	46	93.00 (41.50)	49	68.00 (42.90)	12.31	25.00 (8.03, 41.97)
Total (95% CI)	196		186		100.00	7.98 (−0.88, 16.83)

Test for heterogeneity: χ^2=39.63, df=5 (P<0.00001), I^2=84.9%
Test for overall effect: Z=1.76 (P=0.008)

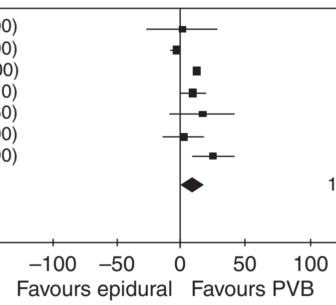


Fig 6 A meta-analysis of trials comparing PVB with epidural analgesia on postoperative respiratory function, expressed as a % of baseline function.

catheter was inserted intraoperatively towards the end of surgery. Our study demonstrated a lower rate of failed technique in the PVB group. For thoracic surgery, surgical placement of the catheter under direct vision would seem to be the most logical solution to avoiding complications and to guarantee drug delivery to the desired location. Unfortunately, our analysis provides no evidence as to which method of PVB is best and further work is required in this area.

There was variability in the additional postoperative analgesics used and the drugs administered into the paravertebral and epidural spaces. Clearly the best drug and drug concentration has yet to be established, although most would probably favour a local anaesthetic only solution. Whatever the best dose, multimodal postoperative analgesia is a cornerstone of treatment for major thoracic and upper abdominal surgery.

There were no large randomized trials comparing PVB with epidural blockade. Despite extensive searching of the literature, we could only find 10 relevant studies so that this meta-analysis included only 520 patients. Not every study contained the outcome information that we desired, despite contacting the original authors for further data. We were unable to include each study for every outcome variable. Therefore, each outcome measure includes only a subset of the 10 selected studies. Some of the studies used thoracic epidural anaesthesia with local anaesthetic only, whereas a combination of local anaesthetic and opioid can provide superior analgesia with epidural techniques. We identified variable effects (heterogeneity) in some of the study endpoints, which limits the ability to analyse pooled data. In these cases, we used a random effects model in the meta-analysis, but heterogeneity is recognized as a weakness in such analyses.[12] Negative studies are less likely to be submitted or accepted for publication and considerable variation can exist between studies in terms of different interventions and different clinical circumstances.[12] In this meta-analysis, there were different methods of placement of the PVBs, the analgesic agents used and the parameters evaluated. However, despite these weaknesses, meta-analysis is considered a reliable source of evidence. The primary endpoint and main adverse effects results were not affected by heterogeneity or lower-quality studies.

Our analysis represents a least-biased attempt to pool the results of several independent studies in order to determine if PVB offers any advantage over epidural analgesia for major surgery. A large, prospective, randomized trial is necessary to confirm these findings. This would ideally be multi-centred in view of the relatively few centres performing PVB.

In conclusion, this systematic review found no difference in analgesia with PVB techniques when compared with epidural regimens. PVB was associated with improvements in respiratory function and a reduction in complications. It appears that PVB is advantageous and can be recommended for major thoracic and upper abdominal surgery.

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