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Review Article

Thoracic paravertebral blocks in abdominal surgery – a systematic review of randomized controlled trials

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Abstract

Thoracic paravertebral blocks (TPVBs) have an extensive evidence base as part of a multimodal analgesic strategy for thoracic and breast surgery and have gained popularity with the advent of ultrasound guidance. However, this role is poorly defined in the context of abdominal surgery. We performed a systematic review of randomized controlled trials, to clarify the impact of TPVB on perioperative analgesic outcomes in adult abdominal surgery. We identified 20 published trials involving a total of 1044 patients that met inclusion criteria; however there was significant heterogeneity in terms of type of surgery, TPVB technique, comparator groups and study quality. Pain scores and opioid requirements in the early postoperative period were generally improved when compared with systemic analgesia, but there was insufficient evidence for any definitive conclusions regarding comparison with epidural analgesia or other peripheral block techniques, or the benefit of continuous TPVB techniques. The reported primary block failure rate was 2.8% and the incidence of complications was 1.2% (6/504); there were no instances of pneumothorax. TPVB therefore appears to be a promising analgesic technique for abdominal surgery in terms of efficacy and safety. But further well-designed and adequately powered studies are needed to confirm its utility, particularly with respect to other regional anaesthesia techniques.

Key words: analgesia; nerve block; regional anesthesia

There has been a resurgence of interest in thoracic paravertebral block (TPVB) in recent years, particularly with the introduction of ultrasound-guided techniques which have made it more accessible to the wider anaesthesia community.[1] There are a multitude of applications for TPVB in anaesthetic practice, including acute pain,[2] chronic pain,[3–5] surgical anaesthesia[6–10] and perioperative analgesia in both breast[11] and thoracic surgery.[12]

Although most work on TPVB has focused on its application to breast and thoracic surgery, it is a potentially useful technique in abdominal surgery as well. The abdominal wall is innervated by the lower thoracoabdominal nerves (T6-T12) and anaesthesia or analgesia can be provided by TPVB performed at these levels. There is however relatively little evidence for TPVB in this setting. A recent systematic review of TPVB for intraoperative surgical anaesthesia identified eight studies, of which only two were directed at abdominal surgery.[8] Another systematic review for TPVB in abdominal surgery focused only on a single surgical procedure (open inguinal herniorraphy) in adult and paediatric populations.[13] The role of TPVB in patients undergoing abdominal surgery therefore remains poorly defined. The goal of the present systematic review was to determine the efficacy of TPVB in providing postoperative analgesia for abdominal surgery when compared with either systemic analgesia alone or alternative analgesic strategies.

Methods

A systematic review of the literature was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (PRISMA) guidelines.[14]

Search strategy

We defined a comprehensive search strategy to identify studies that used TPVB in adult (>18 yr of age) patients undergoing abdominal surgery of any type (Supplementary data, Appendix S1). The following databases were searched: *Medline* (1946 – January 2016), *Medline In-Process* (January 2016), *Embase* (1947 – January 2016), *Cochrane Central Register of Controlled Trials* (January 2016), *Cochrane Database of Systematic Reviews* (2005 – January 2016) and *NHS Economic Evaluation Database* (1st Quarter 2016). Reference lists of selected articles were also hand-searched for additional studies.

Eligible studies

Two authors independently screened the results of the literature search and selected studies that fulfilled the following inclusion criteria: *adult subjects, randomized controlled trial (RCT); postoperative pain scores and/or postoperative analgesic consumption reported; analgesic effect of TPVB distinguishable from other concomitant analgesic modalities*. Studies that did not meet inclusion criteria and abstracts that were not available as English full-text articles were excluded at this stage. Any disagreements regarding article inclusion was resolved by discussion amongst all authors.

Data extraction

Data collection was performed using a standardized form and analysed using Microsoft Excel 2016 (Microsoft Corp, Redmond, WA). The following data was extracted from the selected studies: patient characteristics, type of surgery, study methodology, anaesthetic and analgesic techniques and outcomes assessed. The primary outcomes of interest for this systematic review were postoperative pain scores and/or analgesic intake. Secondary outcomes included length of hospital stay and all adverse events, including nausea and vomiting, vascular puncture, epidural or intrathecal spread, pleural puncture, or pneumothorax. Subgroup analyses based on the type of surgery and comparator technique were performed. Methodological bias of each RCT was assessed independently using the both the modified Jadad five-point scale[15] (which focuses on adequacy of randomization and blinding) and the Cochrane Collaboration risk of bias assessment tool,[16] and tabulated using Review Manager version 5.3 (RevMan; Cochrane Collaboration, Oxford, UK).

Results

Description of studies

Results of literature search

913 citations were retrieved by the initial database search with one additional study identified by hand searching. 158 duplicates were found, leaving 756 records. Of these, 20 studies involving a total of 1044 participants met our inclusion criteria (Fig. 1).

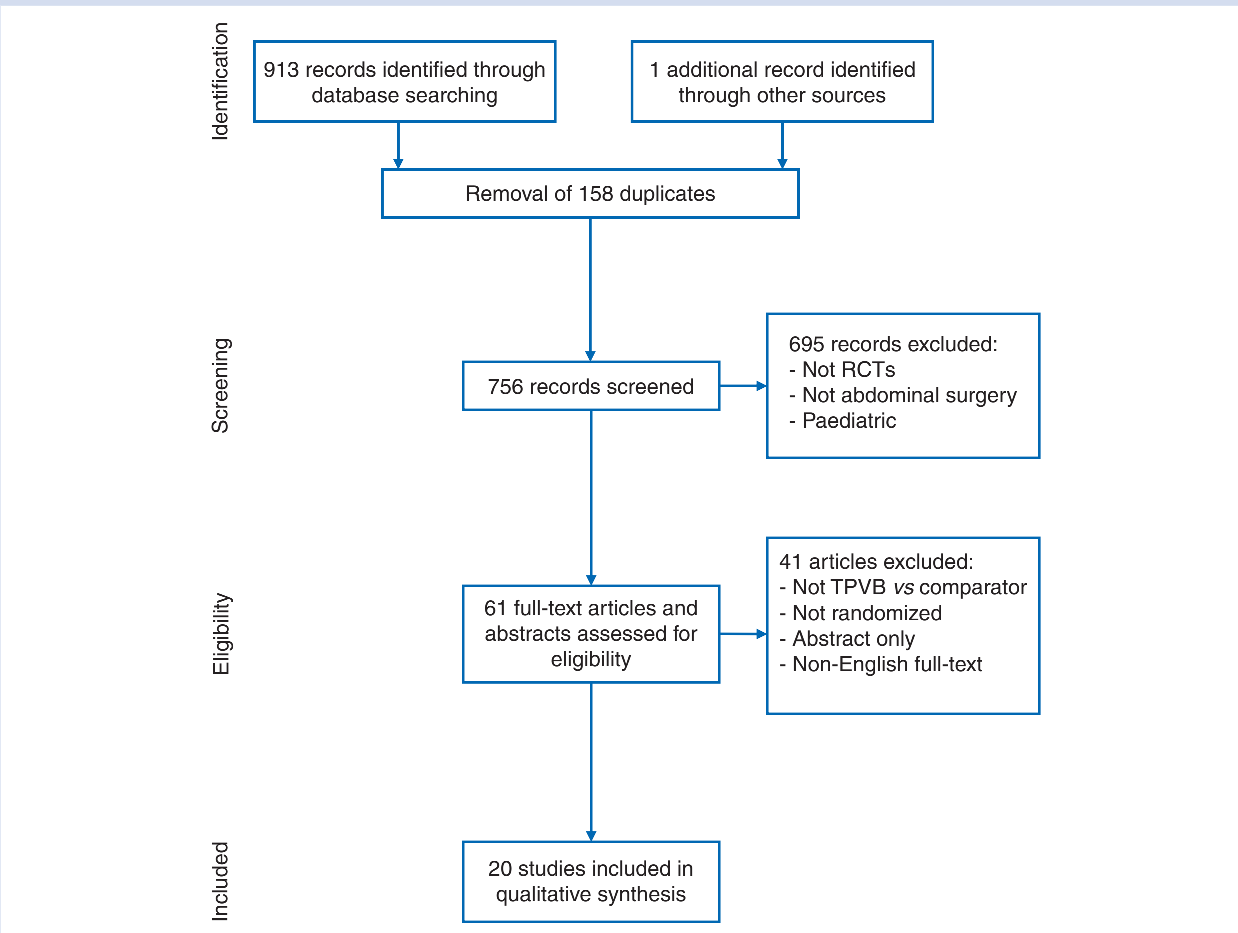

Fig 1 Flowchart of identified, screened, eligible and included studies.

Study quality

The methodological quality of the studies varied widely as judged by the modified Jadad score[15]; eight studies had a Jadad score of five, four had a score of four, whilst eight studies had a score of three or less. When risk of bias was assessed using the Cochrane Collaboration methodology,[16] all but two studies[17 18] were scored as being at high risk of bias in at least one domain. The main areas of weakness were in blinding (performance and detection bias), and unclear reporting of outcome data (Fig. 2).

Technical performance

All studies performed preoperative TPVB in awake patients. Seventeen studies used a landmark-guided insertion technique to perform TPVB. Seven of these used a pre-specified distance beyond the transverse process as their endpoint for injection,[17–23] six studies reported using loss-of-resistance as their endpoint,[24–29] and four used a peripheral nerve stimulator to confirm entry into the paravertebral space.[30–33] Three studies used an ultrasound-guided technique to perform TPVB.[34–36]

Eight studies performed TPVB injections at a single intervertebral[18 19 24–27 34 36] and 12 studies did so at multiple levels.[17 20–23 28–33 35] Four studies inserted paravertebral catheters,[19 25 27 29] however only three of these utilized the catheter to provide postoperative analgesia as either the initial bolus injection,[25] a continuous infusion[27 29] or a second bolus.[19]

Type of surgery

Nine types of surgical procedure in the included studies were identified and distributed as follows: eight studies in open inguinal herniorrhaphy[17 21–24 28 32 36]; three studies in percutaneous nephrolithotomy (PCNL)[19 20 25]; two studies in open renal surgery[26 34]; two studies in laparoscopic cholecystectomy[30 31]; and one study each in open cholecystectomy,[27] donor hepatectomy,[18] ventral wall hernia repair,[29] open major gynaecological surgery[35] and extracorporeal shock wave lithotripsy (ESWL).[33]

Anaesthesia vs analgesia

Nine studies used TPVB as the primary anaesthetic technique.[17 22–25 28 29 33 36] In the other 11 studies TPVB was used in the intervention group solely to provide perioperative analgesia.[18–21 26 27 30–32 34 35]

Comparators

Of the 11 studies using TPVB as an analgesic technique, six studies compared postoperative outcomes after TPVB to systemic analgesia or placebo,[18–20 30 31 34] and two studies compared it to epidural analgesia (either single shot[26] or a continuous infusion[27]). Two studies compared outcomes after transversus abdominis plane (TAP) block to TPVB analgesia,[32 35] and one compared peripheral local anaesthetic infiltration to TPVB.[21]

Of the nine studies using TPVB as a primary anaesthetic technique, four studies compared postoperative analgesic outcomes of TPVB to spinal anaesthesia,[22 24 28 36] and three studies compared it to general anaesthesia (GA) with systemic analgesia alone[17 23 29] One study compared TPVB to local anaesthetic infiltration alone,[33] and the last compared continuous TPVB anaesthesia and analgesia to either continuous lumbar epidural anaesthesia or GA without any supplemental technique.[25]

Outcomes studied

All 20 studies meeting inclusion criteria reported postoperative pain scores for varying time intervals, ranging from PACU to 12 weeks. Postoperative analgesic consumption was reported in all but two of the 20 studies[21 33] but again, this was over varying time intervals. Seventeen studies reported monitoring for adverse outcomes related to TPVB.[17–24 26–30 32–34 36] Three studies reported on length of stay in either PACU or hospital.[17 29 33]

Study	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personal (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Abou Zeid et al 2004 [29]	?	+	−	+	+	−	−
Agarwal et al 2012 [30]	?	?	−	?	+	+	?
Akcaboy et al 2009 [22]	?	+	−	−	+	+	?
Akcaboy et al 2010 [23]	+	+	−	−	+	+	+
Ak et al 2013 [20]	?	+	+	+	−	+	−
Baik et al 2013 [34]	+	+	−	+	+	+	+
Bhattacharya et al 2010 [24]	?	+	−	+	+	+	+
Bigler et al 1989 [27]	?	+	−	−	+	+	+
Borle et al 2014 [19]	+	+	−	+	+	+	+
Elbealy et al 2008 [25]	+	?	−	−	+	+	?
Fusco et al 2016 [36]	+	+	−	+	+	+	+
Hadzic et al 2006 [17]	?	+	?	+	+	+	+
Hanoura et al 2013 [33]	?	+	−	+	+	+	?
Kaya et al 2014 [32]	+	+	−	?	+	+	−
Klein et al 2002 [21]	+	+	−	+	?	?	−
Mandal et al 2011 [28]	?	+	−	+	+	+	?
Melnikov et al 2012 [35]	+	?	−	+	+	?	+
Moawad et al 2013 [26]	?	+	−	−	−	+	+
Moussa 2008 [18]	?	+	+	+	+	+	?
Naja et al 2004 [31]	?	+	−	+	+	+	+

Fig 2 Risk of bias assessment for included randomized controlled trials.

Table 1 Characteristics of studies included in qualitative analysis. LMG, landmark-guided; LOR, loss of resistance; NS, nerve stimulator; PCA, patient-controlled analgesia; SS, single shot; TAP, transversus abdominis plane; TPVB, thoracic paravertebral block; USG, ultrasound-guided

Study details							TPVB details		
Author	Year	Jadad Score[15]	Surgery	N	Control (n)	Intervention (n)	TPVB Level	Number of Injections	Drug administered Per injection
General Surgery									
Akcaboy and colleagues[23]	2010	3	Open inguinal herniorrhaphy	60	General anaesthesia (30)	Unilateral LMG SS-TPVB only (30)	T9-L1	Multiple (5)	5 ml 0.5% Levobupivacaine +Epinephrine×5
Akcaboy and colleagues[22]	2009	3	Open inguinal herniorrhaphy	60	Spinal (30)	Unilateral LMG SS-TPVB only (30)	T9-L1	Multiple (5)	5 ml 0.5% Levobupivacaine +Epinephrine×5
Bhattacharya and colleagues[24]	2010	5	Open inguinal herniorrhaphy	60	Spinal (30)	Unilateral LMG-NS SS-TPVB only (28)	L1	Single	20 ml 0.5% Bupivacaine
Fusco and colleagues[36]	2016	5	Open inguinal herniorrhaphy	50	Spinal (25)	Unilateral USG SS-TPVB only (25)	T9	Single	20 ml 0.5% Levobupivacaine
Hadzic and colleagues[17]	2006	4	Open inguinal herniorrhaphy	48	General anaesthesia (24)	Unilateral LMG SS-TPVB only (24)	T9-L1	Multiple (5)	5 ml 0.5% Levobupivacaine×5
Kaya and colleagues[32]	2014	3	Open inguinal herniorrhaphy	60	TAP block(30)	Unilateral LMG-NS SS-TPVB +general anaesthesia (30)	T11-L1	Multiple (3)	5 ml 0.5% Bupivacaine×3
Klein and colleagues[21]	2002	5	Open inguinal herniorrhaphy	46	Peripheral/Field Block (22)	Unilateral LMG SS-TPVB +general anaesthesia (24)	T10-L2	Multiple (5)	7 ml 0.5% Ropivacaine +Epinephrine×5
Mandal and colleagues[28]	2011	4	Open inguinal herniorrhaphy	54	Spinal (24)	Unilateral LMG-LOR SS-TPVB alone (22)	T10 & L1	Multiple (2)	15 ml 0.5% Bupivacaine×1, 5 ml 0.5% Bupivacaine×1
Agarwal and colleagues[30]	2012	2	Laparoscopic cholecystectomy	50	General anaesthesia (25)	Bilateral LMG-NS SS-TPVB +general anaesthesia (25)	T5-6	Multiple (2)	0.3 ml kg^{-1} 0.25% Bupivacaine×2
Naja and colleagues[31]	2004	3	Laparoscopic cholecystectomy	60	General anaesthesia (30)	Bilateral LMG-NS SS-TPVB +general anaesthesia (30)	T5-6	Multiple (2)	0.3 ml kg^{-1} of mixture including 6 ml 2% Lidocaine, 6 ml 2% Lidocaine/Epinephrine 1:200 000 5 ml 0.5% bupivacaine, 50 mcg Fentanyl, 300 mg clonidine×2
Bigler and colleagues[27]	1989	5	Open cholecystectomy	20	Thoracic epidural analgesia (10)	Unilateral LMG-LOR TPVB catheter+general anaesthesia (10)	T7-8	Single	15 ml 0.5% Bupivacaine
Moussa[18]	2008	5	Donor hepatectomy	24	General anaesthesia (12)	Bilateral LMG SS-TPVB+general anaesthesia (12)	T7-8	Single	25 ml 0.25% Bupivacaine
Abou Zeid and colleagues[29]	2004	2	Ventral hernia repair	60	General anaesthesia (30)	Bilateral LMG-LOR TPVB catheter alone (30)	T9-11	Multiple (2)	20 ml of mixture including 6 ml 2% Lidocaine, 13 ml Levobupivacaine/ Epinephrine 5 mcg ml^{-1}, 50 mcg Fentanyl

Urological Surgery									
Ak and colleagues[20]	2013	4	Percutaneous nephrolithotomy	60	General anaesthesia / Placebo TPVB (28)	Unilateral LMG SS-TPVB +general anaesthesia (27)	T10-12	Multiple (3)	4 ml 0.5% Bupivacaine×3
Borle and colleagues[19]	2014	4	Percutaneous nephrolithotomy	48	General anaesthesia (24)	Unilateral LMG TPVB catheter +general anaesthesia (24)	T10	Single	20 ml 0.5% Bupivacaine
Elbealy and colleagues[25]	2008	3	Percutaneous nephrolithotomy	60	General anaesthesia (20) or epidural (19)	Unilateral LMG-LOR TPVB catheter alone (18)	L1-2	Single	25 ml 0.5% Bupivacaine
Hanoura and colleagues[33]	2013	5	Extracorporeal show wave lithotripsy	50	Local anaesthesia Infiltration (25)	Unilateral LMG-NS SS-TPVB alone (25)	T8-L1	Multiple (6)	5 ml 0.5% Bupivacaine×6
Baik and colleagues[34]	2013	5	Open nephrectomy	34	PCA (17)	Unilateral USG SS-TPVB +general anaesthesia (17)	T10 or T11	Single	18 ml 0.75% Ropivacaine
Moawad and colleagues[26]	2013	1	Open renal surgery	80	Epidural single shot (40)	Unilateral LMG-LOR SS-TPVB +general anaesthesia (40)	T10	Single	1.5 mg kg^{-1} 0.5% Bupivacaine
Gynaecological Surgery									
Melnikov and colleagues[35]	2012	5	Open major gynecological midline surgery	60	TAP block (19)	Bilateral USG SS-TPVB+general anaesthesia (19)	T10	Multiple (2)	0.25 ml kg^{-1} 0.375% Bupivacaine +Epinephrine×2

Data analysis

Meta-analysis of the data was not performed because of the significant heterogeneity in the included studies with regard to type of surgery, comparator groups and definition, measurement and reporting of analgesic outcomes. A qualitative review was undertaken instead. The key characteristics and findings of individual studies are summarized in Tables 1 and 2.

General surgery

Inguinal hernia surgery

Eight studies involving a total of 438 patients compared TPVB in open inguinal herniorrhaphy.[17 21–24 28 32 36] Six studies totalling 332 patients used TPVB as the primary anaesthetic technique[17 22–24 28 36] whilst two studies of 106 patients used TPVB as an analgesic technique.[21 32]

Studies using TPVB as the primary anaesthetic technique. Four studies compared TPVB to spinal anaesthesia as the primary anaesthetic technique.[22 24 28 36] The TPVB groups demonstrated lower resting and dynamic pain scores in the early postoperative period (up to 12 h), with modest reductions in analgesic requirements and less PONV. Fusco and colleagues[36] also reported improved pain outcomes up to 12 weeks postoperatively.

Two studies compared GA to TPVB anaesthesia.[17 23] They reported improved resting and dynamic pain scores during the first 12 postoperative h in the TPVB group, reduced analgesic requirements, and faster time to discharge.

Studies using TPVB as an analgesic technique. There were two studies comparing TPVB to peripheral nerve block techniques. One trial of 46 patients compared TPVB to combined ilioinguinal/iliohypogastric nerve block and subcutaneous infiltration of the surgical site; both groups received standardized GA.[21] There were no reported differences in pain scores at any time point in the first 72 h, but fewer patients in the TPVB group required opioids in PACU.

Another group[32] compared TPVB to TAP block in 60 patients undergoing inguinal herniorrhaphy under spinal anaesthesia. They reported lower pain scores in the TPVB group in the first 12 h, and lower diclofenac consumption compared with the TAP group.

Cholecystectomy

Two studies compared bilateral TPVB to systemic analgesia in a total of 110 patients undergoing laparoscopic cholecystectomy under GA.[30 31] Agarwal and colleagues[30] reported lower pain scores in the TPVB group in PACU, with no differences at any time point between groups thereafter. Analgesic intake was reduced in the TPVB group in the first 24 h postoperatively. However, Naja, Ziade and Lönnqvist[31] reported lower pain scores both at rest and with movement for the first 72 postoperative h, with reduced analgesic requirement for up to 36 h in the TPVB group when compared with systemic analgesia. Both studies reported reduced PONV in their respective TPVB groups.

Bigler and colleagues[27] compared continuous TPVB to continuous thoracic epidural analgesia for open cholecystectomy patients. They demonstrated higher pain scores in the first eight h during coughing, and the first six h at rest in the TPVB group, with higher postoperative systemic morphine consumption in this cohort.

Ventral hernia surgery. One study[29] compared bilateral TPVB catheters as the primary anaesthetic technique to systemic analgesia after GA, in 60 patients with undergoing ventral hernia

Table 2 Outcomes reported from studies included in qualitative analysis. *statistically significant. Data presented as (mean SD) or (median [interquartile range]). NRS, numerical rating score; PACU, post-anaesthesia care unit; PCA, patient controlled analgesia; PONV, postoperative nausea and vomiting; TAP, transversus abdominis plane; TPVB, thoracic paravertebral block VAS, visual analogue score

Study details		Pain scores		Analgesic intake		Other outcomes
Author	Yr	Favours TPVB?	Pain scores TPVB *vs* other	Favours TPVB?	Analgesic intake scores TPVB *vs* other	Other outcomes, complications and failures
General Surgery						
Akcaboy and colleagues[23]	2010	Y	- Lower VAS than systemic analgesia alone at rest & movement first 12 h* - No significant differences at 18, 24 & 48 h	Y	- Fewer patients needing meperidine than systemic analgesia alone in PACU (0 *vs* 8)* - Longer time to first analgesia (naproxen) than systemic analgesia alone(16 h [14.5–17.5] *vs* 3 h [1–7])* - Longer time to first rescue analgesia (tramadol) than systemic analgesia alone(19 h [16–24] *vs* 5.5 h [1–9])* - Fewer patients requiring rescue analgesia* - Longer mean duration of analgesia (15 [5–23] *vs* 3 h [0–6])*.	- Faster readiness to home in TPVB group - No differences in patient or surgeon satisfaction between groups
Akcaboy and colleagues[22]	2009	Y	- Lower VAS than spinal at rest & movement at 4, 6 & 12 h* - No significant differences at 30, 60, 120, 180 mins, 18, 24 & 48 h	Y	- Fewer patients using tramadol than spinal (7 (24.1% *vs* 25 (83.3%))* - Lower mean tramadol usage than spinal group [0.4(0.7) *vs* 1.7(0.7)]*	- Faster readiness to home in TPVB group - No differences in patient satisfaction between groups - 2 patients with epidural spread in TPVB group - 1 TPVB failure - excluded
Bhattacharya and colleagues[24]	2010	Y	- Lower VAS than spinal at 4 h* and 6 h* only	N	- No significant differences in analgesic intake	- Less PONV (6 *vs* 2 in TPVB group - 2 TPVB failures - excluded
Fusco and colleagues[36]	2016	Y	Lower VAS than spinal at 2, 4, 8, 12 & 24 h and at 1, 4, 8 & 12 weeks both at rest* and activity*	Y	- Fewer patients using ketorolac than spinal group from time of surgeryup to 12 weeks (11 *vs* 18)* - Fewer patients using tramadol than spinal group from time of surgeryup to 12 weeks (1 *vs* 15) - No significant differences in acetaminophen use	- Higher patient satisfaction in the TPVB than spinal anaesthesia group* - Reduced dysesthesia, allodynia and hyperesthesia in TPVB group for up to 12 weeks
Hadzic and colleagues[17]	2006	Y	- Fewer reports of moderate-severe pain than systemic analgesia alone in PACU* - Longer median time to first pain (VAS>3) (14 h [1–23] *vs* 2 h [0–8])* - No significant differences at 24, 48 or 72 h	N	- No significant difference in number of pain pills	- More nausea in systemic analgesia group but only 1 patient had vomiting

Kaya and colleagues[32]	2014	Y	- Lower VAS than TAP in PACU, 30 min, 3, 6 & 12 h*	Y	- More patients using diclofenac in TAP group (66% *vs* 35%)*	- Faster readiness to home in TPVB group
Klein and colleagues[21]	2002	N	- No significant differences for the first 72 h	Y	- Fewer patients needing opioids in PACU than peripheral block (39% *vs* 61%)*	- 1 patient with epidural spread in TPVB group
Mandal and colleagues[28]	2011	Y	- Unclear from description	Y	- Lower 24 h total tramadol requirement than spinal group[126±(54) mg *vs* 172(35) mg]* - Longer time to first analgesic request than spinal group [216(22) min *vs* 334(71) min]*	- 2 TPVB failures- excluded - 2 TPVB inadequate - excluded - 2 spinal failure – excluded - 2 spinals bilateral - excluded
Agarwal and colleagues[30]	2012	Y	- Lower 1st PACU VAS at rest [5.68 (1.34) *vs* 3.64(1.57)] & with coughing than systemic analgesia alone [5.24(1.5) *vs* 7.04 (1.24)]* - No significant differences at 2,6,12 & 24 h	Y	- Lower 24 h morphine intake than systemic analgesia alone[16.8(3.37) mg *vs* 27.24 (5.08) mg]*	- Less PONV in the immediate postoperative period in the TPVB group
Naja and colleagues[31]	2004	Y	- Lower VAS than systemic analgesia alone at rest at 6 and 12 h* and during movement, coughing and walking at 6, 12, 24, 36 and 48 h*	Y	- Fewer patients needing analgesic supplementation (dextropropoxifen ±meperidine) than systemic analgesia alone at 6, 12, 24 & 36 h*	- No significant difference in PONV
Bigler and colleagues[27]	1989	N	- Higher pain scores than epidural during coughing at 2, 4, 6 & 8 h*, and at 6 h* at rest	N	- Higher morphine intake than epidural (15 mg [0–25] *vs* 0 mg [0–15])*	- No differences in impairment of pulmonary function - 1 patient with segmental thoracic pain for >3 months in TPVB group - 2 TPVB failures - excluded
Moussa[18]	2008	Y	- Lower median VAS than systemic analgesia alone on PACU admission (5 *vs* 2) and discharge (4 *vs* 1)*	Y	- Lower morphine consumption than systemic analgesia alone in PACU[4.1 (1.16) *vs* 9.21(2.18)]* and at 24 h [21.76(6.8) mg *vs* 44.12(9.2) mg]* - Longer time to first analgesic requirement than systemic analgesia alone[104.08 (2.04) min *vs* 31.5(6.14) min]*	- Less PONV in TPVB group
Abou Zeid and colleagues[29]	2004	Y	- Lower VAS than systemic analgesia alone at 0–24 h (0 *vs* 7) and 24–48 h (2 *vs* 6) (Not significant)	Y	- Lower analgesic intake than systemic analgesia alone at 24 and 48 h*	- Less PONV* in TPVB group - shorted length of stay 4 (1.2) *vs* 7 (1.3)*

Continued

Table 2 *Continued*

Study details		Pain scores		Analgesic intake		Other outcomes
Author	**Yr**	**Favours TPVB?**	**Pain scores TPVB *vs* other**	**Favours TPVB?**	**Analgesic intake scores TPVB *vs* other**	**Other outcomes, complications and failures**
Urological Surgery						
Ak and colleagues[20]	2013	Y	- Lower VAS than systemic analgesia alone at 1 & 2 h* - No significant differences at 6, 12 & 24 h	Y	- Lower 24 h morphine intake than systemic analgesia alone[22.3(6.1) *vs* 43.2(9.5)]* - Longer time than systemic analgesia alone to first PCA use [94.2(24.1) *vs* 48.3(17.4)]*	- Higher patient satisfaction in TPVB group [4.2 (0.6)] than systemic analgesia alone [2.4 (0.5)]* on a 5-point scale - Less nausea* (but not vomiting) in TPVB group - 3 failed TPVB - excluded - 2 patients in the systemic analgesia group unable to use PCA - excluded
Borle and colleagues[19]	2014	Y	- Lower VAS than systemic analgesia alone at rest at 0, 1, 2 & 12 h* and with deep breathing at 0, 1, 2, 4, 6, 12 & 24 h*	Y	Lower median postoperative fentanyl consumption than systemic analgesia alone(525 mcg [150–1275] *vs* 175 mcg [25–475])* Lower mean tramadol boluses on the ward than systemic analgesia alone[1.95(0.8) *vs* 1.04(0.53)]* Longer median time to first analgesic request than systemic analgesia alone(30 min [0–180] *vs* 120 min [30–570])*	- One patient with hydropneumothorax in each group
Elbealy and colleagues[25]	2008	Y	- Lower VAS than both epidural and systemic analgesia at 0, 2, 4, 6, 12 and 24 h*	Y	- Lower number of patients consuming analgesia than in epidural(2 *vs* 13)* and systemic analgesia (20 *vs* 13)* groups	- Lower PONV in TPVB & epidural group than systemic analgesia group - 2 failed TPVB - excluded - 1 failed epidural - excluded
Hanoura and colleagues[33]	2013	N	- No significant differences up to discharge from PACU	Not reported	- Not reported	- Shorter PACU stay - Higher patient satisfaction in TPVB group [8.8(1.1)] than local anaesthesia alone [6.1(0.6)]* on a 10-point scale
Baik and colleagues[34]	2013	Y	- Lower NRS than systemic analgesia alone at 1, 3, 6, 12 & 24 h*	Y	- Lower fentanyl consumption than systemic analgesia alone in the first 24 h(1,122.8 mcg [267.8] *vs* 711.5 mcg [307])*	
Moawad and colleagues[26]	2013	N	- No significant differences for the first 24 h	N	- No significant differences for the first 24 h	- 1 patient with intravascular spread in TPVB group
Gynaecological Surgery						
Melnikov and colleagues[35]	2012	Y	- Lower NRS than systemic analgesia at rest and with coughing at all time points until 48 h* - Lower NRS than TAP block only with coughing at 2 h*	Y	- Lower ketobemidon use than systemic analgesia alone at 6, 24 and 48 h* - Lower ketobemidon use than TAP group at 24 & 48 h*	

repair. The TPVB group received a postoperative infusion of 0.125% bupivacaine with 1 mcg ml^{-1} fentanyl through each catheter for 48 h, whereas the GA group only received non-steroidal anti-inflammatory drugs (NSAIDs) and opioid analgesia as required. Not surprisingly, oral analgesic requirement was higher in the GA group in the first 24 h (100% *vs* 0%) and the 24–48-h period (90% *vs* 7%). Pain scores were lower in both time periods in the TPVB group, but there was no comment on the statistical significance of this result. The incidence of PONV was also lower, with a trend towards lower hospital stay in the TPVB group.

Donor hepatectomy. One study compared single shot bilateral TPVBs with placebo blocks in a population of 24 patients undergoing donor hepatectomy under GA.[18] Pain scores were significantly lower on PACU admission and discharge (two h postoperatively) in the TPVB group, but were not assessed thereafter. Time to first analgesic requirement was significantly longer (mean 104 *vs* 32 min), whilst morphine consumption in PACU and in the first 24 h was also significantly reduced in the TPVB group.

Urological surgery

Percutaneous nephrolithotomy (PCNL)

Two studies of 108 patients compared TPVB to systemic analgesia for postoperative analgesia[19 20] after PCNL under GA. A third triple-armed study of 60 patients compared TPVB, GA, and single-shot thoracic epidural block as the primary anaesthetic technique for PCNL.[25] Pain scores were reduced in the TPVB groups compared with systemic analgesia or single shot thoracic epidural block for between two[20] and 24 h.[25] There was a reduction in opioid consumption and less PONV in TPVB patients in all three studies.

Open renal surgery

Baik and colleagues[34] compared TPVB with systemic analgesia in patients having elective open nephrectomy under general anaesthesia. Pain scores and opioid requirements were significantly lower in the TPVB group for up to 24 h, although PONV was equivalent between both groups.

Another group compared TPVB to single shot thoracic epidural block for open renal surgery, including nephrectomy, pyelolithotomy and pyeloplasty.[26] Analgesic requirements and pain scores were reported to be similar between both groups for the first 24 h.

Extracorporeal shock wave lithotripsy

Hanoura and colleagues[33] compared TPVB to local anaesthetic infiltration in patients undergoing outpatient extracorporeal shock wave lithotripsy (ESWL) under sedation. There was no reported difference in pain scores throughout the intraoperative phase or in PACU, although fentanyl consumption was lower in the TPVB group. Additionally, PACU time was significantly shorter in the TPVB group [99(17) min *vs* 133(31) min].

Gynaecological surgery

Melnikov and colleagues[35] compared TPVB to either bilateral ultrasound-guided TAP block or systemic analgesia alone in patients undergoing midline laparotomy for gynaecological cancer. Compared with the PCA group, both TPVB and TAP groups had reduced opioid consumption and lower resting and dynamic postoperative pain scores up to 24 h after surgery. TPVB had a greater effect than TAP block on postoperative analgesic outcomes at 24 and 48 h, with pain scores remaining lower in the TPVB group compared with the PCA group up to 48 h postoperatively.

Other outcomes

Five studies reported patient satisfaction outcomes.[20 22 23 33 36] Of these, three reported higher satisfaction scores in the TPVB groups compared with systemic analgesia alone,[20] local anaesthesia[33] or spinal anaesthesia.[36] Two studies reported no difference in patient satisfaction between TPVB and either systemic analgesia alone[23] or spinal anaesthesia.[22] No studies reported cost-effectiveness or population-based outcomes.

Complications

Out of the 504 adult patients in this review who received a TPVB, there were 14 patients excluded for block failure (2.8%).[20 22 24 25 27 28] This included nine failures (3.7%) out of the 241 TPVBs administered for surgical anaesthesia. The endpoint for needle insertion in the 14 block failures were as follows: pre-determined distance beyond the transverse process (four patients),[20 22] motor response to nerve stimulation (two patients),[24] or loss-of-resistance (eight patients).[25 27 28] The reported failure rate for each of these techniques was therefore 2.3% (4/175 blocks), 1.7% (2/115 blocks) and 5.2% (8/153 blocks) respectively. There were no reported failures among the 61 ultrasound-guided TPVBs.

There was one report of hydropneumothorax (which may have been related to the surgery (PCNL) rather than the block),[19] one report of intravascular puncture,[26] and three patients with epidural spread.[21 22] There was one report of segmental thoracic pain lasting three months after TPVB.[27] There were no reported cases of pneumothorax.

Discussion

Our systematic review identified 20 published randomized controlled trials examining the role of TPVB in adults undergoing abdominal surgery. The largest number of studies (eight) were in open inguinal herniorrhaphy,[17 21–24 28 32 36] with a limited number of studies (one to three) for other types of surgery. The synthesis and interpretation of these studies was hampered by heterogeneity in methodology, including type of surgery, comparator techniques, and outcome definition, assessment and reporting. Several of these studies also suffered from methodological and data reporting issues that limit the conclusions that can be drawn from their results.

Notwithstanding this, the overall available evidence points to improved early postoperative analgesic outcomes for TPVB in comparison to systemic analgesia alone in most operative procedures. In recent yr, the use of regional anaesthesia in abdominal surgery has been dominated by abdominal wall plane blocks, in particular the TAP block and its variants. The advent of minimally-invasive surgical techniques, along with the ubiquity of aggressive postoperative thromboprophylaxis, have done much to reduce the role of epidural analgesia and techniques such as the TAP block have been embraced as simpler and safer analgesic alternatives. TPVB may offer a useful middle ground between neuraxial blocks and abdominal wall plane blocks for major open abdominal surgery, as they can provide both visceral and somatic analgesia. They may also provide more extensive coverage of the abdominal wall than plane blocks; TAP blocks, for example, do not generally cover incisions extending lateral to the mid-clavicular or anterior axillary line, and thus have a more limited scope of application.[37] There are however very few trials at present comparing TPVB to other peripheral nerve block techniques such as TAP block[32 35] or ilioinguinal-iliohypogastric block[21] for abdominal surgery. While these suggest that TPVB provides superior analgesic outcomes, more work is needed before a definitive recommendation can be made. There were only three studies that compared TPVB to thoracic epidural analgesia, of which one reported analgesic outcomes in favour of thoracic epidural block,[27] one found no difference[26] and one found TPVB to be superior.[25] All three looked at different surgical populations and used different anaesthetic and analgesic regimens. No conclusions can therefore be drawn regarding the relative efficacy of TPVB and thoracic epidural analgesia in abdominal surgery at present. Finally, the newer quadratus lumborum block techniques purport to provide abdominal analgesia by spread to the thoracic paravertebral space,[38 39] but there are presently no comparative trials to indicate whether this is advantageous over direct injection of local anaesthetic into the thoracic paravertebral space.

The relatively short duration of analgesia (12–24 h) is an expected limitation of any single shot peripheral nerve block technique. Three studies in this review inserted TPVB catheters[25 27 29] but only two of these used the catheter to provide postoperative analgesia.[27 29] Abou Zeid and colleagues[29] were able to extend the analgesic benefit of TPVB up to 48 h with continuous local anaesthetic infusion. Bigler and colleagues[27], on the other hand, noted that continuous local anaesthetic infusion failed to maintain the extent of block that was achieved with the initial bolus, and that continuous TPVB provided inferior analgesia compared with continuous thoracic epidural analgesia in the setting of open cholecystectomy. Challenges with TPVB catheters, such as catheter tip malposition have been observed in up to 30% of TPVB catheters inserted using the landmark-guided technique and up to a quarter provide inadequate analgesia.[40] More studies are needed to determine if modifications in insertion technique (e.g. the use of ultrasound) or the use of different catheter designs can address these limitations.[41]

The analgesic benefits of TPVB must be weighed against the relative complexity and complications associated with the technique. Fourteen failed TPVBs (2.8%) were reported in the studies included in this review, nine of which were failures of surgical anaesthesia. The block failure rate was highest with a loss-of-resistance technique (5.2%). The superior costotransverse ligament is a less dense structure compared with the ligamentum flavum and may not completely span the gaps between transverse processes. The loss of resistance encountered upon entering the thoracic paravertebral space is therefore more subtle than when entering the epidural space,[42] which may make it a less reliable endpoint. Advancing the block needle a pre-determined distance beyond contact with the transverse process was associated with a 2.3% failure rate, which may be because of inherent inter-individual anatomical variation. Notably, there were no failures reported in studies using the newer ultrasound-guided techniques, although the small number of blocks (n=61) preclude any definitive conclusions about relative efficacy at this time.[30–33] On the other hand, the majority of studies did not report systematically assessing patients for block success, and concurrent administration of general anaesthesia may have masked TPVB failure. It is therefore possible that the overall therapeutic failure rate for postoperative analgesia is higher than what has been reported. The overall adverse event rate was low (1.2%), with one of the six reported events (hydropneumothorax) possibly related to surgery rather than TPVB. In particular there were no cases of pneumothorax, and this may partly reflect the fact that the anterior boundary of the paravertebral space in lower TPVB approaches is the diaphragm, rather than the pleura.[1] While this low complication rate contrasts with older published data,[43] it is in keeping with more contemporary literature,[44] and supports an increased role for TPVB in abdominal surgery.

In order to fully understand the therapeutic effects of TPVB in abdominal surgery, we recommend that future randomized controlled trials should be designed with the following methodological standards: a) patients having major abdominal surgery; b) standardized TPVB technique; c) comparing TPVB with both placebo blocks and alternative regional anaesthetic techniques such as epidural, TAP block or quadratus lumborum block; d) optimal multimodal analgesia in both groups, including regular acetaminophen, NSAIDs and breakthrough opioid analgesia; e) adequately powered to detect a clinically significant difference in pain scores and analgesic requirement up to at least 24 h postoperatively; f) rigorous surveillance for adverse effects and complications associated with the block.

Conclusion

In summary, our systematic review identified a relatively small number of studies examining the analgesic efficacy of TPVB in abdominal surgery. The evidence indicates that single-shot TPVB provides postoperative analgesia in the first 12 to 24 h, reducing pain scores, opioid consumption, and PONV compared with patients who receive no block. The reported block failure rate was less than 3% and complications were uncommon. Although the majority of published studies were in open inguinal herniorrhaphy, we would not consider this a major indication for TPVB given the availability and widespread use of other less-invasive anaesthetic approaches. Instead TPVB may have potential as an alternative regional anaesthesia technique in major abdominal surgery, particularly where both somatic and visceral analgesia is desired. However, there are insufficient data at present to determine how TPVB compares to thoracic epidural analgesia, or other abdominal wall block techniques. Further well-designed studies are required to fully elucidate the role that TPVB may have in postoperative analgesia after abdominal surgery.

Authors' contributions

Study design/planning: C.M., K.J.C.
Study conduct: K.E., C.M., K.J.C.
Data analysis: K.E., K.J.C.
Writing paper: K.E., K.J.C.
Revising paper: all authors

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Declaration of interest

None declared.

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