British Journal of Anaesthesia **111** (5): 721–35 (2013)
Advance Access publication 27 June 2013 · doi:10.1093/bja/aet214

BJA

Duration of analgesic effectiveness after the posterior and lateral transversus abdominis plane block techniques for transverse lower abdominal incisions: a meta-analysis

F. W. Abdallah[1,2]*, J. G. Laffey[1,2], S. H. Halpern[1,3] and R. Brull[1,4,5]

[1] Department of Anesthesia, University of Toronto, ON, Canada
[2] Department of Anesthesia and Keenan Research Centre, Li Ka Shing Knowledge Institute, St Michael's Hospital, Toronto, ON, Canada
[3] Department of Anesthesia, Sunnybrook Hospital, Toronto, ON, Canada
[4] Department of Anesthesia, Women's College Hospital, Toronto, ON, Canada
[5] Department of Anesthesia, Toronto Western Hospital, Toronto, ON, Canada

* Corresponding author: Department of Anaesthesia, St Michael's Hospital, 30 Bond Street, Toronto, ON, Canada M5B 1W8.
E-mail: abdallahf@smh.ca

Editor's key points

- The duration of effectiveness of transversus abdominis plane (TAP) block in providing postoperative analgesia after abdominal surgery was studied in this meta-analysis.
- The authors conclude that TAP block using the posterior approach reduced the rest and dynamic pain as well as the consumption of morphine for up to 48 h.
- The effect was not seen when a TAP block was performed using the lateral approach.
- The authors call for randomized controlled trials, which will compare the two approaches of performing a TAP block.

Background. Both posterior and lateral transversus abdominis plane (TAP) block techniques provide effective early (0–12 h) postoperative analgesia after transverse incision surgery. However, whether either technique produces prolonged analgesia lasting beyond 12 h remains controversial. This meta-analysis examines the duration of analgesia associated with posterior and lateral TAP blocks in the first 48 h after lower abdominal transverse incision surgery.

Methods. We retrieved randomized controlled trials (RCTs) investigating the analgesic effects of TAP block compared with control in patients undergoing lower abdominal transverse incision surgery. Outcomes sought included interval postoperative i.v. morphine consumption and also rest and dynamic pain scores at 12, 24, 36, and 48 h postoperatively. Opioid-related side-effects and patient satisfaction at 24 and 48 h were also assessed. The 12–24 h interval morphine consumption was designated as a primary outcome.

Results. Twelve RCTs including 641 patients were analysed. Four trials examined the posterior technique and eight assessed the lateral technique. Compared with control, the posterior TAP block reduced postoperative morphine consumption during the 12–24 h and 24–48 h intervals by 9.1 mg (95% CI: −16.83, −1.45; P=0.02) and 5 mg (95% CI: −9.54, −0.52; P=0.03), respectively. It also reduced rest pain scores at 24, 36, and 48 h, and also dynamic pain scores at 12, 24, 36, and 48 h. Differences were not significant with the lateral TAP block.

Conclusion. Based on the comparisons with control, the posterior TAP block appears to produce more prolonged analgesia than the lateral TAP block. Future RCTs comparing these two techniques are required to confirm our findings.

Keywords: acute pain, novel techniques; anaesthetic blocks, regional; analgesia, postoperative; regional blockade; surgery, abdominal

Accepted for publication: 17 April 2013

Patients undergoing obstetric or gynaecological surgery using transverse lower abdominal incisions, such as the Pfannenstiel, Cherney, and Maylard[1 2] incisions, often suffer severe pain during the first 48 h postoperatively.[3–5] Not surprisingly, the incidence of persistent postoperative pain, an undesirable outcome of surgery influenced by the duration and efficacy of postoperative analgesia,[6] after Caesarean delivery[7] and total abdominal hysterectomy[8] approaches 12 and 32%, respectively. As the abdominal wall is a major contributor to acute postoperative pain after abdominal surgery,[9] field blocks like the transversus abdominis plane (TAP) block[10] can provide effective analgesia for a variety of abdominal surgical procedures.[11 12] However, the relative efficacy of the TAP block for transverse lower abdominal incisions may vary depending on the block technique.[12] While posterior injections in the triangle of Petit and lateral injections at the midaxillary line techniques have both demonstrated efficacy in the immediate postoperative period,[12] the potential for either technique to produce more prolonged analgesic benefits (≥12 h) after lower transverse incision surgery remains controversial. A recent retrospective review[13]

suggests that prolonged post-Caesarean delivery analgesia lasting into the 24–48 h postsurgical period can be achieved by performing the lateral TAP block technique. In contrast, several clinical trials[14–16] and a recent qualitative systematic review[12] suggest that only the posterior TAP block technique provides prolonged analgesia. This meta-analysis examines the effect of each TAP block technique on analgesic outcomes in the first 48 h after laparotomy surgeries with a lower abdominal transverse incision.

Methods

The authors abided by the PRISMA guidelines[17] in the preparation of this review. We used a pre-determined protocol to review and evaluate the results of randomized controlled trials (RCTs) that measured the duration of analgesic effectiveness of the TAP block.

Eligibility criteria

We sought and retrieved full reports of RCTs that investigated the effects of TAP block (TAP group) compared with placebo or systemic analgesia (control group) on analgesic outcomes in patients undergoing abdominal surgery using a lower abdominal transverse incision.

Literature search

The US National Library of Medicine database, MEDLINE; the Excerpta Medica database, Embase; Cochrane Database of Systematic Reviews; and Cochrane Central Register of Controlled Trials databases were searched by two of the authors (F.W.A. and R.B.) independently. The search terms TAP/TAP block/Transversus Abdominis/Transverse Abdominis/Transversus Abdominis Plane block/and Transverse Abdominis Plane block alone and coupled with the search keywords 'lateral' and 'posterior' were queried. The results of the search were combined by the Boolean operator AND with medical subject headings analgesia/pain relief/pain control/pain prevention/and pain management and with the medical subject headings abdomen/abdominal wall/abdominal muscles/abdominal surgery/and abdominal incision. We also hand searched the bibliographies of included articles for additional RCTs that met the inclusion criteria. The search was limited to RCTs on human subjects published between January 2005 and December 2012; no language restrictions were imposed. RCTs were excluded if analgesic outcomes were not assessed, if surgeries other than lower abdominal transverse incision were performed, if unilateral or continuous TAP blocks were performed, or if adjuvants that may prolong the duration of nerve block analgesia were used. Trials examining the subcostal TAP block technique were not included as it does not provide analgesia for lower abdominal transverse incisions.[18] The decision on inclusion of qualifying studies in the review was obtained by consensus between two of the authors (F.W.A. and R.B.).

Data collection and presentation

Two of the authors (F.W.A. and R.B.) independently assessed the quality of the reviewed RCTs using the Jadad score,[19] and a final score was designated by consensus. An RCT was considered to be of good quality if the methodological score was between 3 and 5. As an additional indicator of quality, only trials with a sample size >10 per group and that maintained a concealed assignment were considered. For the purpose of this review, we evaluated interval opioid analgesic consumption (converted to i.v. morphine equivalent)[20] and also pain severity at rest and with movement [visual analogue scale (VAS), a 100 mm scale where 0 represents no pain and 100 represents maximum pain] at 12, 24, 36, and 48 h postoperatively. We also assessed the incidence of opioid-related adverse effects (postoperative nausea and vomiting, pruritus, and excessive sedation) and patient satisfaction at 24 and 48 h. The 12–24 h interval postoperative cumulative morphine consumption was designated as a primary outcome; and other outcomes were classified as secondary. The authors independently used a standardized data collection form to extract data; any discrepancies were resolved by re-examination of the source data.

Meta-analysis

Two of the authors (F.W.A. and R.B.) entered and cross-checked the data into the statistical programme. Meta-analytic techniques (Revman 5.1, Cochrane Library, Oxford, UK) were used to combine the data where possible. The random effect modelling was utilized in analysing both dichotomous and continuous data. Data from trials with more than two intervention groups receiving TAP block were combined into a single group as recommended by the Cochrane Handbook.[21] We calculated the odds ratio (OR) and 95% confidence interval (CI) for the dichotomous outcomes, and the standardized mean difference and 95% CI for the continuous outcomes. Differences were considered statistically significant if the 95% CI of OR excluded 1, or if the 95% CI excluded 0 for the standardized mean difference. We verified the extent of heterogeneity using the I^2 statistic.[22]

As prolonged analgesia has been attributed to the posterior technique,[14–16] we hypothesized—*a priori*—that combining the results of trials using the posterior and lateral techniques would generate significant heterogeneity among the pooled trials. We, therefore, performed subgroup analysis according to the TAP block technique.

Additional confounding factors that were identified *pre hoc* as potential sources of heterogeneity included differences in the population studied (pregnant or non-pregnant), and the use of intrathecal morphine in some trials. When data relating to the primary outcome (i.e. 12–24 h interval postoperative cumulative morphine consumption) were heterogeneous, we explored whether alternative subgrouping based on these pre-determined factors influenced the level of heterogeneity and significance of the treatment effects.

Results

Our search retrieved 29 articles, 12 of which met the inclusion criteria.[14 15 23–32] Figure 1 summarizes the retrieved, excluded, and reviewed RCTs. The median and range of the methodological quality score[19] of the 12 trials were 5 (3–5); and they included a total of 641 patients for analysis: 329 patients in

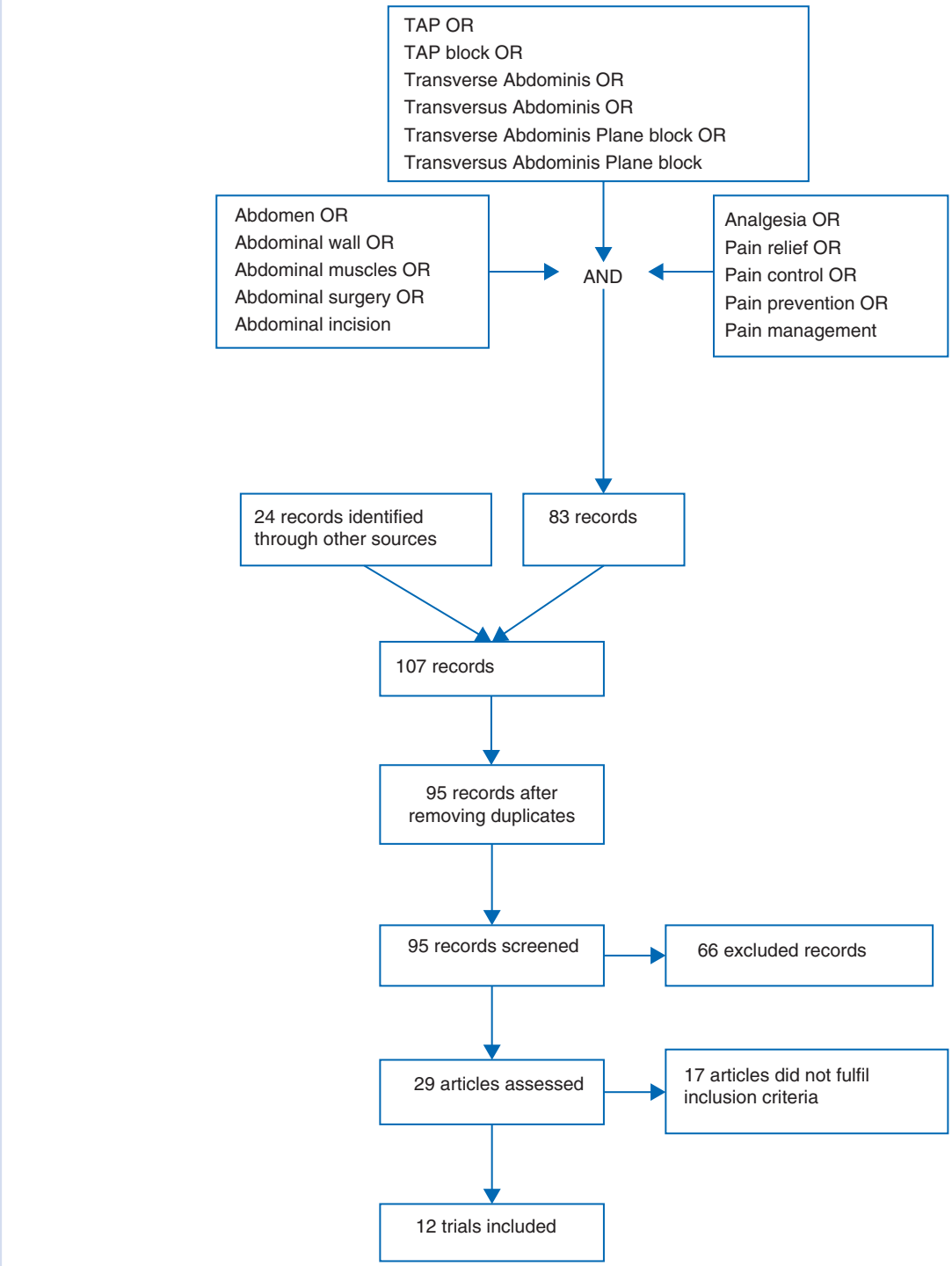

Fig 1 Flow chart summarizing retrieved, included, and excluded RCTs.

the TAP group and 312 in the control group. Table 1 presents the trial characteristics and outcomes assessed for each trial. Four trials had TAP blocks performed using the posterior technique,[14 15 27 31] while another eight used the lateral technique.[23–26 28–30 32] None of the trials compared the posterior and the lateral techniques; and the separation of results into two subgroups based on the TAP block technique was found to marginally reduce the heterogeneity of results of the primary outcome from 99 to 97% and 74% for the two subgroups. Alternative subgrouping did not further reduce the heterogeneity. Table 2 describes the TAP block technique and the analgesic regimens used in the trials reviewed. One RCT[26]

Table 1 Outcomes of reviewed trials. GA, general anaesthesia; ITM, intrathecal morphine; PACU, post-anaesthesia care unit

Author/year	Jadad score	Surgery	*N*	Groups (*n*)	Anaesthesia	Primary outcome	Rest pain scores		Dynamic pain scores		Opioid consumption		Time to first analgesic request	Opioid-related adverse effects	Patient satisfaction
							Early	Late	Early	Late	Early	Late			
McDonnell and colleagues, 2008[14]	5	Caesarean delivery	52	1. TAP block (25) 2. Sham block (25)	Spinal	Cumulative 48 h opioid consumption	•	•	•	•	•	•	•	•	
Carney and colleagues, 2008[15]	4	Total abdominal hysterectomy	53	1. TAP block (24) 2. Sham block (26)	GA	Cumulative 48 h opioid consumption	•	•	•	•	•	•	•	•	
Belavy and colleagues, 2009[23]	4	Caesarean delivery	50	1. TAP block (23) 2. Sham block (24)	Spinal	Cumulative 24 h opioid consumption	•		•		•		•	•	•
Costello and colleagues, 2009[24]	5	Caesarean delivery	100	1. TAP block+ITM (49) 2. Sham block+ITM (47)	Spinal	Dynamic pain scores at 24 h	•	•	•	•	•	•			•
Baaj and colleagues, 2010[25]	3	Caesarean delivery	40	1. TAP block (19) 2. Sham block (20)	Spinal	Cumulative 24 h opioid consumption	•		•		•			•	•
McMorrow and colleagues, 2011[26]	5	Caesarean delivery	80	1. TAP block+ITM (20) 2. Sham block+ITM (20) 3. TAP block (20) 4. Sham block (20)	Spinal	Dynamic pain scores (time point not specified)	•	•	•	•	•	•		•	•
Amr and colleagues, 2011[27]	3	Total abdominal hysterectomy	75	1. Pre-incisional TAP block (22) 2. Post-incisional TAP block (22) 3. Sham block (23)	GA	Cumulative 48 h opioid consumption	•	•	•	•	•	•	•	•	
Shin and colleagues, 2011[28]	3	Gynecologic surgery	32	1. TAP block (16) 2. No block (16)	GA	Rest pain scores in PACU	•	•	•	•	•	•		•	•
Atim and colleagues, 2011[29]	5	Total abdominal hysterectomy	60	1. TAP block (18) 2. Sham block (18) 3. Infiltration (19)	GA	Cumulative 24 h opioid consumption	•		•		•				
Tan and colleagues, 2012[30]	5	Caesarean delivery	40	1. TAP block (20) 2. No block (20)	GA	Cumulative 24 h morphine consumption	•		•		•			•	•
Eslamain and colleagues, 2012[31]	5	Caesarean delivery	50	1. TAP block (24) 2. No block (24)	GA	Postoperative pain (time point not specified)	•		•		•		•		
Bollag and colleagues, 2012[32]	5	Caesarean delivery	90	1. TAP block (25) 2. Sham block (30) 3. TAP block+clonidine adjuvant (26)	Spinal	Hyperalgesia at 48 h	•	•	•	•	•	•		•	

Table 2 Analgesic regimen. PCA, patient-controlled analgesia; PACU, post-anaesthesia care unit

Author/year	Surgery	Pre-incisional analgesia	Surgical analgesia	Supplemental postoperative analgesia	TAP block			
					Block timing	Localization	Site of injection	Block solution
McDonnell and colleagues, 2008[14]	Caesarean delivery		Spinal+intrathecal: 25 μg fentanyl	1 dose rectal diclofenac, 1 dose rectal acetaminophen, then i.v. PCA morphine, oral acetaminophen, and rectal diclofenac	Postoperative	Anatomical	Triangle of Petit	1.5 mg kg^{-1} ropivacaine 0.75% to a total dose of 150 mg
Carney and colleagues, 2008[15]	Total abdominal hysterectomy	I.V. morphine, rectal diclofenac, rectal acetaminophen, TAP block in experimental group	I.V. fentanyl, i.v. morphine	I.V. PCA morphine, rectal diclofenac, and rectal acetaminophen	Preoperative	Anatomical	Triangle of Petit	1.5 mg kg^{-1} ropivacaine 0.75% up to a total dose of 150 mg
Belavy and colleagues, 2009[23]	Caesarean delivery		Spinal+intrathecal: 15 μg fentanyl	1 dose rectal diclofenac, 1 dose rectal acetaminophen, then i.v. PCA morphine, oral acetaminophen, and oral ibuprofen	Postoperative	US	Midaxillary line	20 ml ropivacaine 0.5%
Costello and colleagues, 2009[24]	Caesarean delivery		Spinal+intrathecal: 10 μg fentanyl, 100 μg morphine	1 dose i.v. ketorolac, 1 dose rectal acetaminophen, then i.v. morphine, oral diclofenac, and oral acetaminophen	Postoperative	US	Midaxillary line	20 ml ropivacaine 0.375%
Baaj and colleagues, 2010[25]	Caesarean delivery		Spinal+intrathecal: 20 μg fentanyl	I.V. PCA morphine	Postoperative	US	Midaxillary line	20 ml bupivacaine 0.25%
McMorrow and colleagues, 2011[26]	Caesarean delivery		Spinal+intrathecal: 10 μg fentanyl, 100 μg morphine	1 dose rectal paracetamol, 1 dose rectal diclofenac, then i.v. PCA morphine, oral paracetamol, and rectal diclofenac	Postoperative	Anatomical	Midaxillary line	1 mg kg^{-1} bupivacaine 0.375%
Amr and colleagues, 2011[27]	Total abdominal hysterectomy	TAP block in experimental group	I.V. fentanyl	I.V. morphine	Pre-+postoperative	Anatomical	Triangle of Petit	20 ml levobupivacaine 0.375%
Shin 2011[28]	Gynecologic surgery	TAP block in experimental group	I.V. remifentanil	I.V. fentanyl or ketorolac, then ketorolac+sufentanil via i.v. PCA, i.v. meperidine	Preoperative	US	Midaxillary line	20 ml ropivacaine 0.375%
Atim and colleagues, 2011[29]	Total abdominal hysterectomy	I.V. diclofenac	I.V. fentanyl	I.V. tramadol, then i.v. PCA tramadol, and i.m. meperidine	Postoperative	US	Midaxillary line	20 ml bupivacaine 0.25%
Tan and colleagues, 2012[30]	Caesarean delivery		I.V. morphine	I.V. PCA morphine	Postoperative	US	Midaxillary line	20 ml levobupivacaine 0.25%

Continued

Table 2 *Continued*

Author/year	Surgery	Pre-incisional analgesia	Surgical analgesia	Supplemental postoperative analgesia	TAP block			
					Block timing	Localization	Site of injection	Block solution
Eslamaian and colleagues, 2012[31]	Caesarean delivery		I.V. sufentanil, i.v. morphine	I.V. tramadol and rectal diclofenac	Postoperative	Anatomical	Triangle of Petit	15 ml bupivacaine 0.25%
Bollag and colleagues, 2012[32]	Caesarean delivery		Spinal+intrathecal: 25 μg fentanyl, 100 μg morphine	1 dose i.v. ketorolac, i.v. morphine in PACU, then oral acetaminophen, oral diclofenac, and oral tramadol	Postoperative	US	Midaxillary line	20 ml bupivacaine 0.375%

included four groups and performed two comparisons between the TAP block and control groups, in the presence and absence of intrathecal morphine. For the sake of this review, each of the two comparisons was treated as a separate trial. One trial included two TAP block groups[27] ('pre-incisional' and 'post-incisional') that were combined into one for the purpose of this review. Two of the authors whom we contacted provided additional unpublished results pertaining to postoperative morphine consumption.[27 32]

Interval morphine consumption

Results describing postoperative i.v. morphine consumption were available from nine trials for the 0–12 h interval,[14 15 23–27 30] nine trials for 12–24 h,[14 15 23–27 30] two trials for the 24–36 h,[14 26] and two trials for the 36–48 h[14 26] postoperatively. Because so few trials reported morphine consumption at 36 h postoperatively, the 24–36 and 36–48 h intervals sought were combined into one interval (24–48 h) for the purpose of this review. Thus, data reflecting postoperative i.v. morphine consumption during the 24–48 h interval were available from a total of eight trials.[14 15 24 26–28 32]

Compared with the control group, performing the posterior TAP block technique was effective in reducing the interval morphine consumption by 23.2 mg or a relative decrease of 64.5% (95% CI: −27.70, −18.78; $P<0.00001$) at 0–12 h; by 9.1 mg or 51.9% (95% CI: −16.83, −1.45; $P=0.02$) at 12–24 h; and by 5 mg or 63% (95% CI: −9.54, −0.52; $P=0.03$) at 24–48 h postoperatively (Table 3, Fig. 2).

Performing a TAP block using the lateral technique reduced morphine consumption by 8.3 mg or 49.7% (95% CI: −16.64, −0.05; $P=0.05$) at 0–12 h postoperatively (Table 3, Fig. 2). The lateral technique did not differ from control at any other time interval up to 48 h postoperatively.

Morphine consumption data for both the posterior and lateral TAP block subgroups during the 12–24 h interval (primary outcome) were characterized by high heterogeneity ($I^2=95$ and 92%, respectively; $P<0.00001$). The heterogeneity remained when pregnancy and intrathecal morphine use were considered (Fig. 3).

Rest pain

Rest pain was assessed at 12 h in 10 trials,[14 15 23–25 27 28 30–32] at 24 h in 13 trials,[14 15 23–32] at 36 h in 3 trials,[14 15 32] and 48 h in 8 trials.[14 15 24 26–28 32]

Compared with control, performing the posterior TAP block technique reduced the rest pain VAS score by 17 mm at 12 h (95% CI: −21.2, −12.1; $P<0.00001$), by 13 mm at 24 h (95% CI: −21.7, −3.8; $P=0.005$), by 18 mm (95% CI: −22.7, −12.9; $P<0.00001$) at 36 h, and by 15 mm (95% CI: −20.2, −8.9; $P<0.00001$) at 48 h postoperatively (Table 3, Fig. 4).

When a TAP block was performed using the lateral technique, rest pain VAS scores were reduced by 5 mm at 12 h (95% CI: −7.5, −2.8; $P<0.0001$). There was no difference in rest pain scores at 24, 36, and 48 h postoperatively between the lateral technique and control groups (Table 3, Fig. 4).

Table 3 Secondary endpoint results. N/A, not applicable; PONV, postoperative nausea and vomiting

Outcome	Subgroup	Studies included	TAP block mean or *n/N*	Control mean or *n/N*	OR or weighed mean [95% CI]	*P*-value for statistical significance	*P*-value for heterogeneity	I^2 test for heterogeneity
Interval morphine consumption for 0–12 h (mg)	Posterior	14 15 27	11.82	33.34	−23.24 [−27.70, −18.78]	<0.00001	0.002	84%
	Lateral	23–26 30	7.17	14.26	−8.34 [−16.64, −0.05]	0.05	<0.00001	99%
Interval morphine consumption for 12–24 h (mg)	Posterior	14 15 27	7.16	14.88	−9.14 [−16.83, −1.45]	0.02	<0.00001	97%
	Lateral	23–26 30	6.06	8.04	−1.83 [−4.44, 0.77]	0.17	0.002	74%
Interval morphine consumption for 24–48 h (mg)	Posterior	14 15 27	3.36	9.06	−5.03 [−9.54, −0.52]	0.03	<0.00001	95%
	Lateral	24 26 32	5.80	3.49	0.94 [−0.84, 2.71]	0.3	0.04	64%
Rest pain at 12 h (cm)	Posterior	14 15 27 31	1.33	2.88	−1.67 [−2.12, −1.21]	<0.00001	0.003	78%
	Lateral	23–25 28 30 32	1.45	1.84	−0.51 [−0.75, −0.28]	<0.0001	0.19	32%
Rest pain at 24 h (cm)	Posterior	14 15 27 31	0.92	1.98	−1.28 [−2.17, −0.38]	0.005	<0.00001	97%
	Lateral	23–26 28–30 32	1.53	1.76	−0.31 [−0.66, 0.05]	0.09	<0.0001	78%
Rest pain at 36 h (cm)	Posterior	14 15	0.49	2.26	−1.78 [−2.27, −1.29]	<0.00001	0.06	72%
	Lateral	32	1.00	1.00	0.00 [−0.74, 0.74]	1	N/A	N/A
Rest pain at 48 h (cm)	Posterior	14 15 27	1.17	2.19	−1.46 [−2.02, −0.89]	<0.00001	<0.0001	91%
	Lateral	24 26 28 32	1.17	1.06	0.08 [−0.49, 0.65]	0.78	0.0002	82%
Dynamic pain at 12 h (cm)	Posterior	14 15 27 31	3.05	4.59	−1.59 [−1.88, −1.30]	<0.00001	0.36	6%
	Lateral	23 24 28–30 32	2.45	3.04	−0.77 [−1.60, 0.05]	0.07	<0.00001	94%
Dynamic pain at 24 h (cm)	Posterior	14 15 27 31	2.34	4.36	−2.19 [−3.28, −1.10]	<0.0001	<0.00001	90%
	Lateral	23–26 28–30 32	2.53	3.08	−0.75 [−1.52, 0.02]	0.06	<0.00001	94%
Dynamic pain at 36 h (cm)	Posterior	14 15	2.39	3.61	−1.19 [−1.87, −0.52]	0.0006	0.39	0%
	Lateral	32	2.00	2.00	0.00 [−0.80, 0.80]	1.0	N/A	N/A
Dynamic pain at 48 h (cm)	Posterior	14 15 27	1.92	3.83	−2.22 [−3.32, −1.12]	<0.0001	0.0002	88%
	Lateral	24 26 28 32	2.16	2.29	−0.07 [−1.06, 0.92]	0.89	<0.00001	89%
Incidence of PONV at 24 h (*n/N*)	Posterior	14 15 27	27/95	36/73	0.30 [0.05, 1.73]	0.18	0.02	75%
	Lateral	23 25 26 30 32	21/127	30/134	0.65 [0.33, 1.28]	0.21	0.63	0%
Incidence of PONV at 48 h (*n/N*)	Posterior	14 15	0/49	5/51	0.07 [0.00, 1.40]	0.08	N/A	N/A
	Lateral	26 32	3/65	3/70	0.95 [0.18, 4.93]	0.95	0.4	0%
Incidence of pruritus at 24 h (*n/N*)	Posterior	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Lateral	23 26 30 32	61/108	47/114	2.28 [1.22, 4.25]	0.01	0.42	0%
Incidence of pruritus at 48 h (*n/N*)	Posterior	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Lateral	26 32	15/65	14/70	1.15 [0.35, 3.76]	0.82	0.22	33%
Incidence of sedation at 24 h (*n/N*)	Posterior	14 15 27	20/95	38/73	0.23 [0.10, 0.57]	0.001	0.29	19%
	Lateral	23 30 32	34/68	30/74	1.80 [0.67, 4.84]	0.24	0.5	0%
Incidence of sedation at 48 h (*n/N*)	Posterior	14 15 27	0/95	9/73	0.03 [0.00, 0.63]	0.02	N/A	N/A
	Lateral	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Patient satisfaction at 24 h (mm)	Posterior	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Lateral	23 24 26 28	82.20	77.97	6.96 [−5.74, 19.67]	0.28	*P*<0.0001	83%
Patient satisfaction at 48 h (mm)	Posterior	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Lateral	24 26 28	87.83	82.08	3.84 [−6.21, 13.89]	0.45	<0.00001	96%

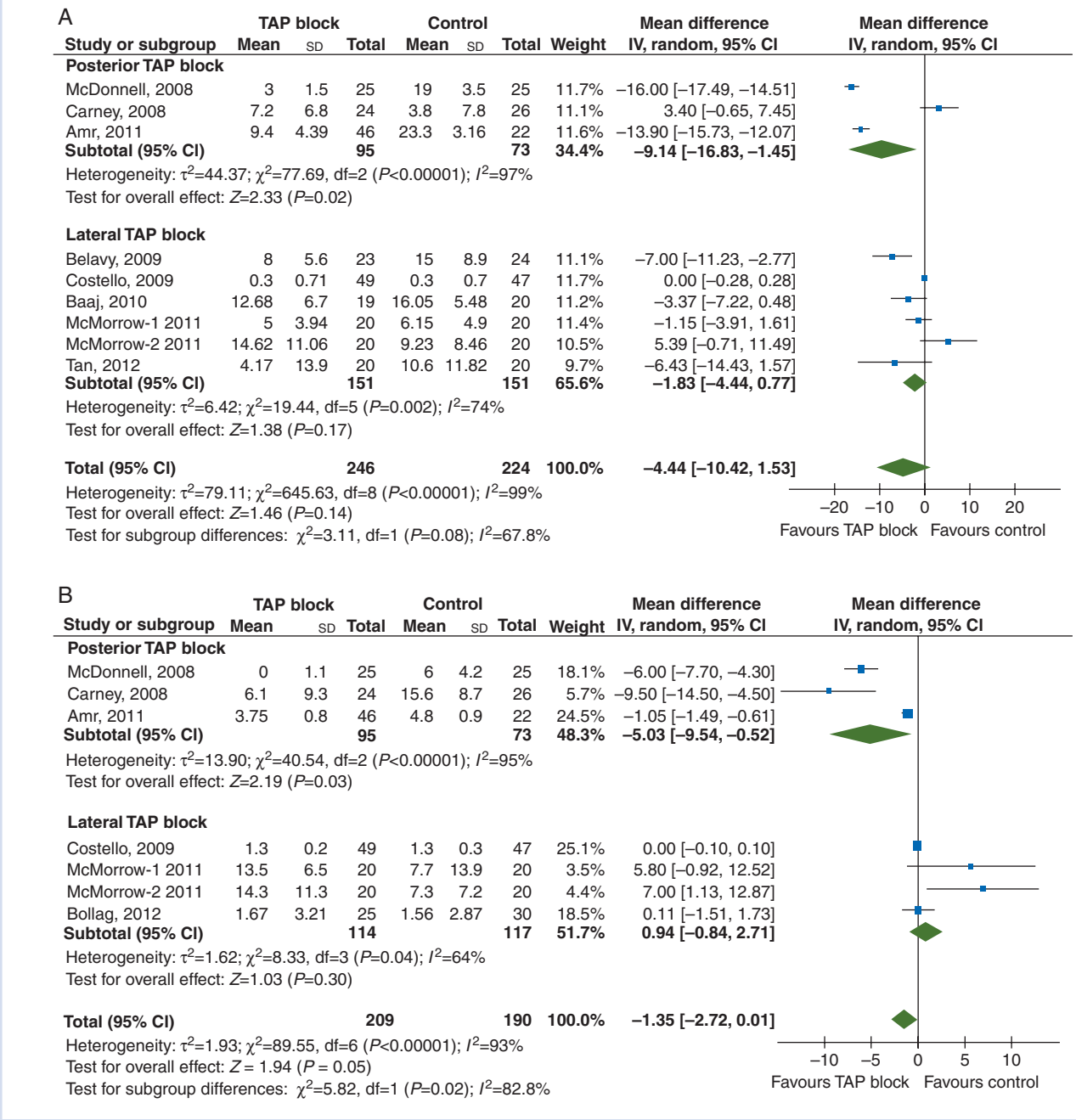

Fig 2 Forest plots of morphine consumption for: (A) 12–24 h interval; (B) 24–48 h interval. The sample size, mean, SDs, and the pooled estimates of the mean difference are shown. The 95% CIs are shown as lines for individual studies and as diamonds for pooled estimates.

Dynamic pain

Dynamic pain was assessed at 12 h in 10 trials,[14 15 23 24 27–32] at 24 h in 13 trials,[14 15 23–32] at 36 h in 4 trials,[14 15 32] and at 48 h in 8 trials.[14 15 24 26–28 32]

Compared with control, the posterior TAP block technique reduced dynamic pain VAS scores by 16 mm at 12 h (95% CI: −18.8, −13.0; $P<0.00001$), by 22 mm at 24 h (95% CI: −32.8, −11.0; $P<0.0001$), by 12 mm at 36 h (95% CI: −18.7, −5.2; $P=0.0006$), and by 22 mm (95% CI: −33.2, −11.2; $P<0.0001$) at 48 h postoperatively (Table 3, Figs 5 and 6).

Performing the lateral TAP block technique did not produce a difference in dynamic pain compared with control at 12, 24, 36, and 48 h postoperatively (Table 3, Figs 5 and 6).

Opioid-related adverse effects

Because of the diversity in the definitions of opioid-related adverse effects in the reviewed trials, the results of these outcomes are reported as 'standardized units'. The incidence of postoperative nausea and vomiting was similar between the TAP block and the control group for both the posterior and

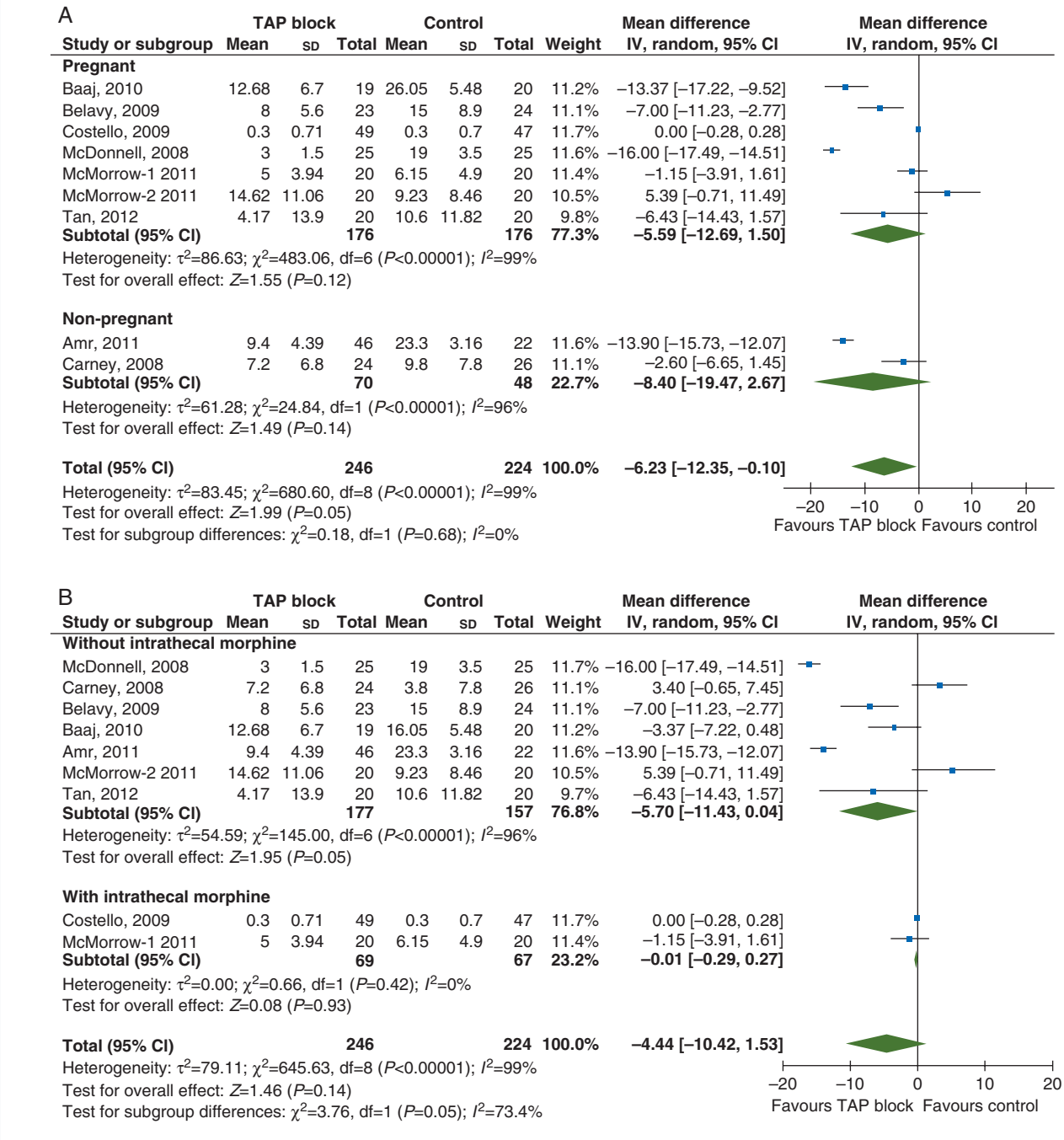

Fig 3 Forest plots depicting alternative subgrouping of the primary outcome (12–24 h interval morphine consumption) according to: (A) pregnancy; (B) use of intrathecal morphine. The sample size, mean, SDs, and the pooled estimates of the mean difference are shown. The 95% CIs are shown as lines for individual studies and as diamonds for pooled estimates.

the lateral techniques at 24 and 48 h (Table 3). The incidence of pruritus in the lateral TAP block technique was increased to an OR of 2.28 (95% CI: 1.22, 4.25; $P=0.01$) at 24 h compared with control, but there was no difference at 48 h. There were no data on the incidence of pruritus for the posterior technique. The incidence of sedation was reduced to an OR of 0.23 (95% CI: 0.10, 0.57; $P=0.001$) at 24 h, and to an OR of 0.03 (95% CI: 0.00, 0.63; $P=0.02$) at 48 h compared with the control group when the posterior TAP block technique was performed; but there was no difference from control at 24 h with the lateral technique. There were no data at 48 h postoperatively.

There were no data related to patient satisfaction for the posterior TAP block technique. For the lateral technique, there were no statistically significant differences in patient

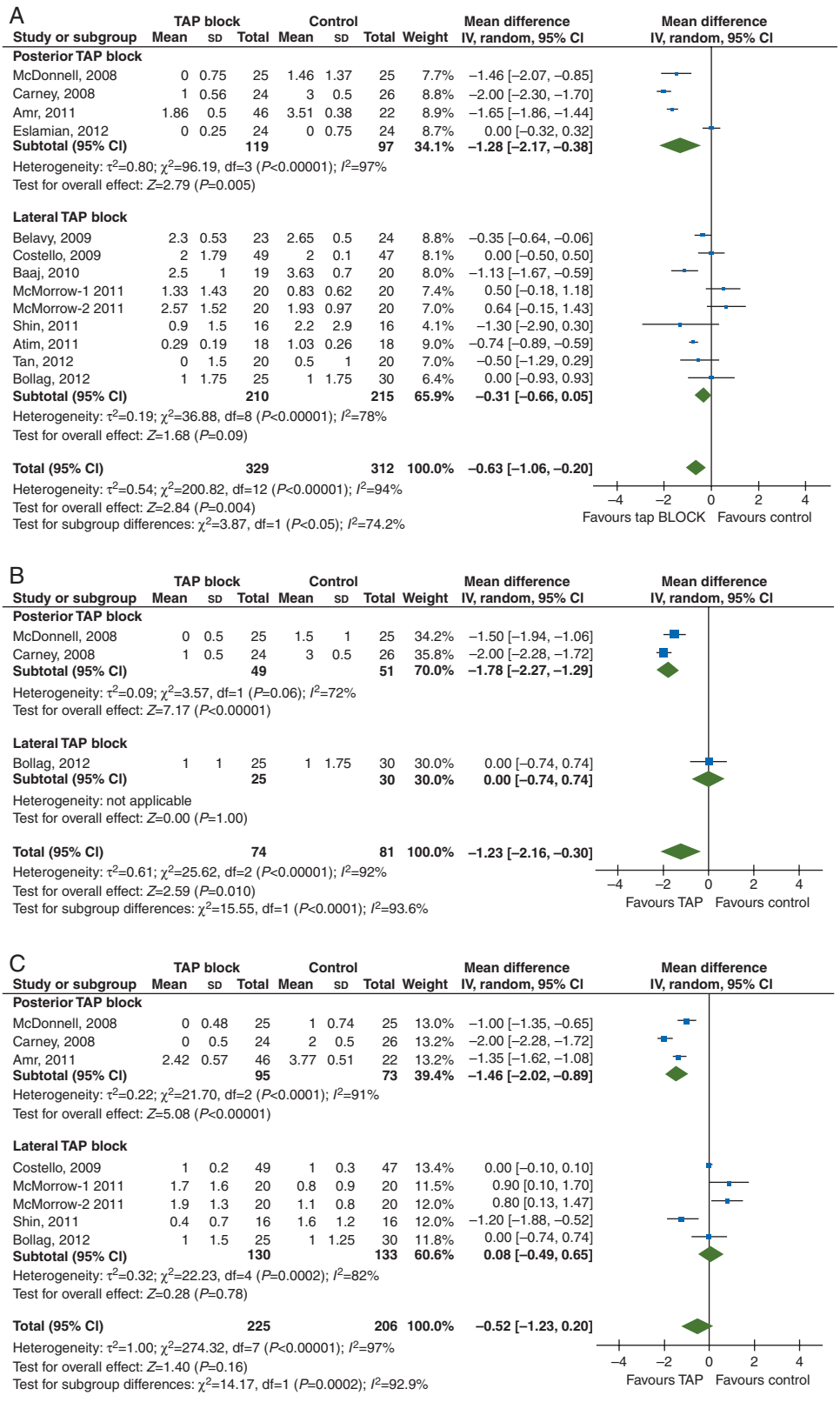

Fig 4 Forest plots of rest pain VAS scores at: (A) 24 h; (B) 36 h; (C) 48 h. The sample size, mean, SDs, and the pooled estimates of the mean difference are shown. The 95% CIs are shown as lines for individual studies and as diamonds for pooled estimates.

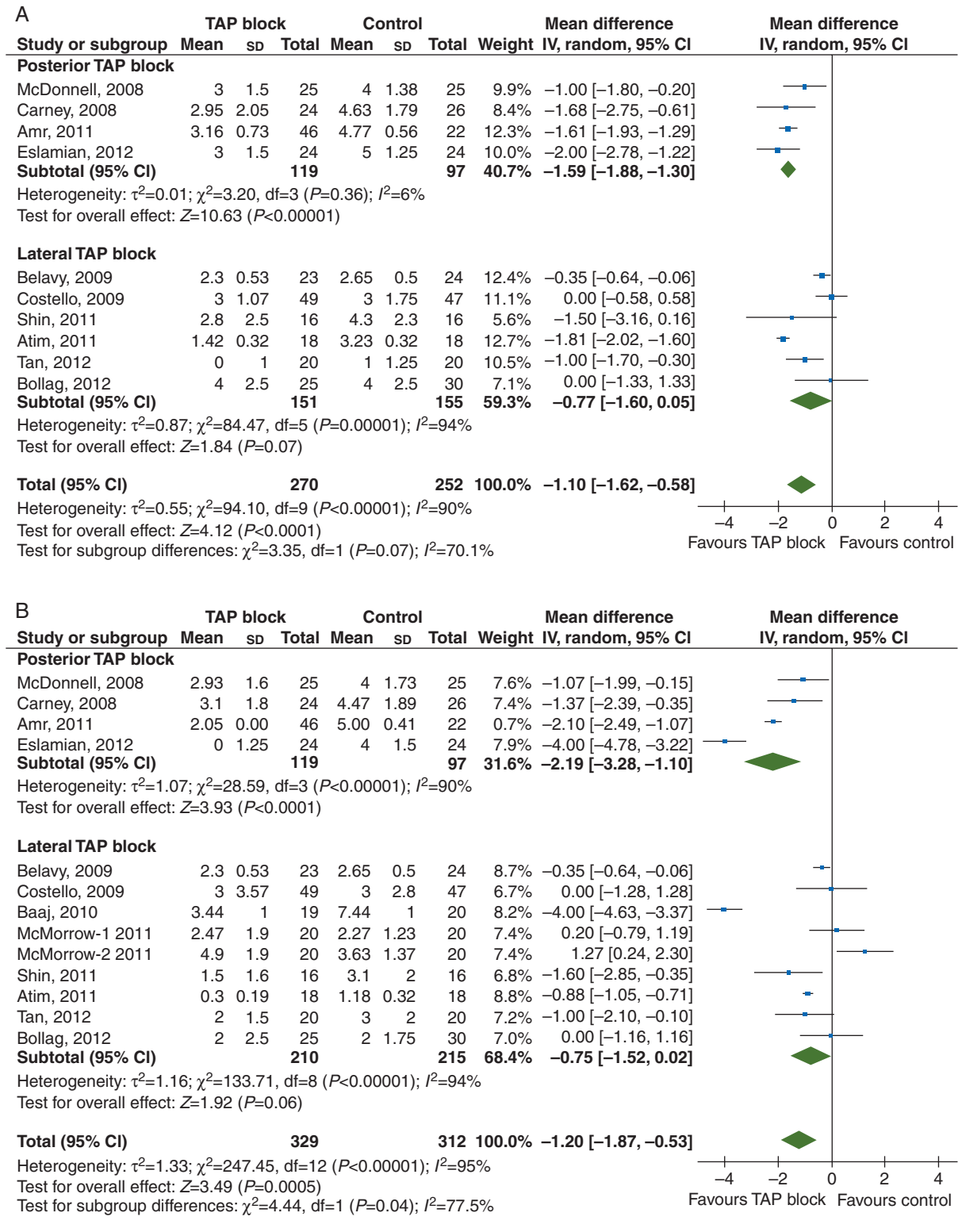

Fig 5 Forest plots of dynamic pain VAS scores at: (A) 12 h; (B) 24 h. The sample size, mean, SDs, and the pooled estimates of the mean difference are shown. The 95% CIs are shown as lines for individual studies and as diamonds for pooled estimates.

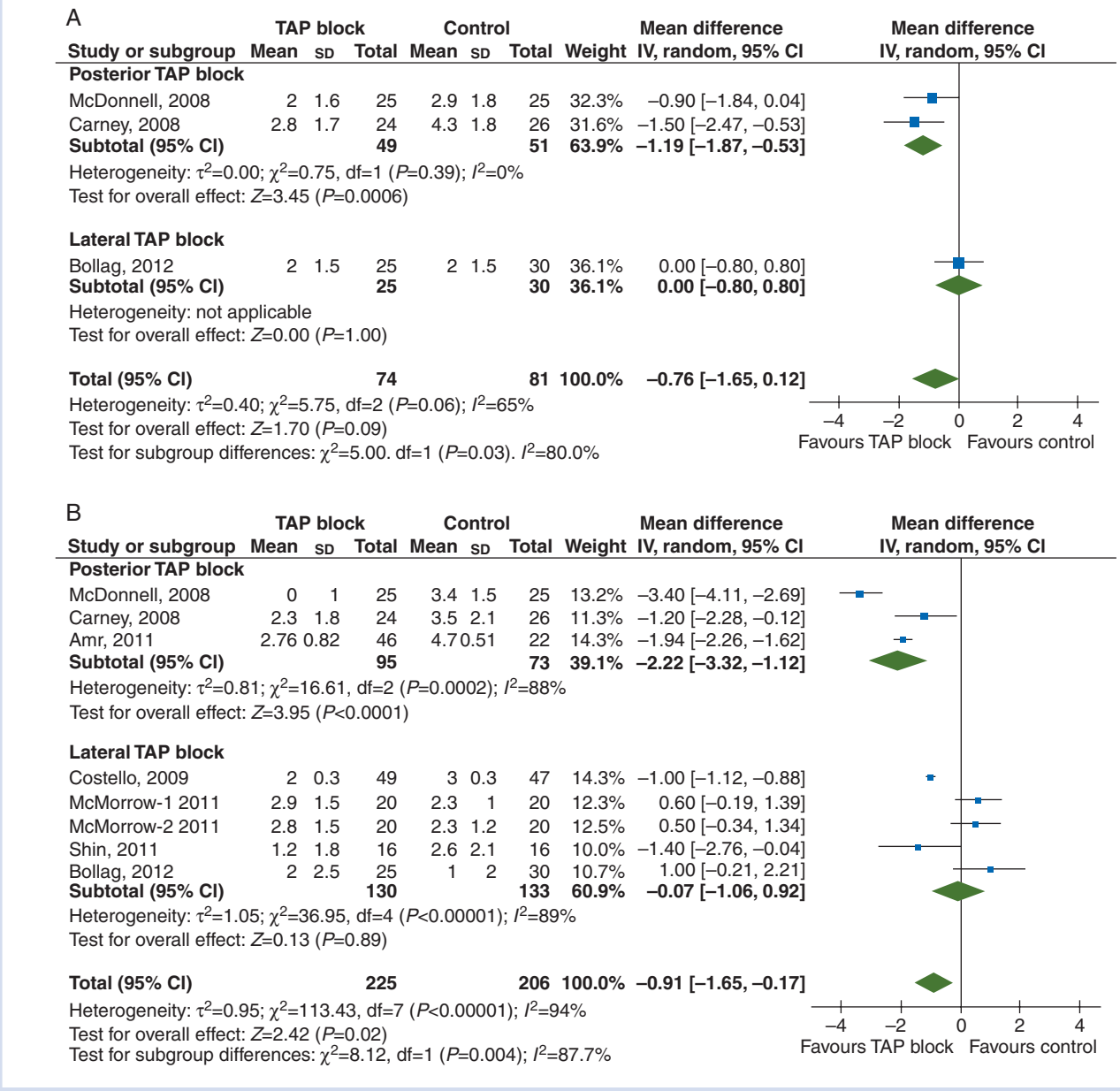

Fig 6 Forest plots of dynamic pain VAS scores at: (A) 36 h; (B) 48 h. The sample size, mean, SDs, and the pooled estimates of the mean difference are shown. The 95% CIs are shown as lines for individual studies and as diamonds for pooled estimates.

satisfaction among the trials that reported this outcome at 24 h[23 24 26 28] and 48 h[24 26 28] when compared with control (Table 3). None of the trials reported any block-related complications.

Other outcomes

It is noteworthy that the effect of TAP block on the incidence of postsurgical chronic pain was evaluated by three trials.[24 27 32] Two trials evaluated the rate of chronic pain after TAP block performed with the lateral technique, which was not different from the control group at 6 weeks,[24] and 3, 6, and 12 months.[32] However, the third trial,[27] which compared pre-incisional with post-incisional TAP block using the posterior technique or no block (control), reported that none of the patients who received a pre-incisional posterior TAP block required analgesics to treat chronic pain at 3 and 6 months, compared with 13.6 and 17.4% for the post-incisional TAP block and control groups, respectively.

Discussion

In the absence of a direct comparison between the two TAP block techniques, and based on the comparison with control, our results suggest that performing the posterior TAP block may be a better technique for prolonged analgesia after

lower abdominal transverse incision surgeries. The posterior technique can reduce opioid consumption, rest and dynamic pain scores, and the incidence of sedation up to 48 h postoperatively.

Several possible explanations may account for these findings. First, a more posterior injection point may allow the TAP block to capture lateral cutaneous branches of thoracolumbar nerves before entering into the TAP where they undergo extensive branching and anastomoses.[33–36] Secondly, the posterior—but not the lateral—technique results in a retrograde local anaesthetic spread that reaches the paravertebral space[37] and extends between the T4-L1 levels within 4 h of injection,[38] potentially producing some degree of block along the thoracolumbar sympathetic chain. Evidence suggestive of a role of the sympathetic nervous system in acute postoperative pain continues to emerge,[39] and sympathetic block may account for the prolonged analgesic effect associated with the posterior technique. Finally, while the formation of a local anaesthetic 'depot' in the neuro-fascial TAP plane[40] might explain the prolonged effects of the TAP block, this possibility has been challenged,[40 41] and in any case would also occur with the lateral technique.

The recent surge of interest in TAP blocks is likely attributable to the advent of ultrasound (US) guidance, as the benefits of US are believed to be related to enhanced accuracy of local anaesthetic deposition.[42] Interestingly, when the present data set was analysed *post hoc* to compare US-guidance to anatomical landmark techniques, we found that anatomically guided TAP blocks, irrespective of location (i.e. posterior or lateral), provided prolonged postoperative analgesia whereas US-guided TAP blocks did not. The latter reflects the fact that all trials that examined the TAP block performed using the posterior technique relied on anatomical localization; and all but one trial[26] where the TAP block was performed using the lateral technique used US guidance. It has been hypothesized that the 'double pop' endpoint[14] used in the anatomical technique is more effective in depositing local anaesthetics deep to the fascia between the internal oblique and the TAP where the thoracolumbar nerves lie[34] compared with the distension of the fascial planes endpoint[43] used in the US technique.[44] However, studies on the local anaesthetic spread cast doubt on this possible explanation, and instead attribute the difference in efficacy to material anatomical differences at the sites of injection resulting in a different spread pattern of injected local anaesthetics rather than the localization technique.[37 45 46]

Our meta-analysis has several limitations. First, none of the trials performed a direct comparison between the posterior and lateral techniques; hence, the observed differences between the two techniques are based on their indirect comparison. A direct comparison of these approaches is needed to provide a definitive answer to this issue. Secondly, the reviewed trials were small and characterized by high heterogeneity. Considerable differences existed in the doses and types of local anaesthetics used in performing the TAP block, in the control groups, and in the patient population. Alternative subgrouping according to, for example, the use of intrathecal morphine or pregnant population subgroup did not reduce the heterogeneity of results. This heterogeneity may limit the clinical combinability of the results. It is also noteworthy that none of the reviewed trials performed a sensory assessment of their patients to confirm block onset or offset; thus, failure of the TAP block cannot be ruled out as an explanation for some of the observed lack of analgesic efficacy. Finally, except for two trials,[27 28] invasive placebo injections were used in the control arms of the reviewed trials. These invasive approaches towards blinding are becoming less acceptable.[47]

In conclusion, while much remains to be learned regarding the TAP block, it does appear that more posterior block approaches may provide more prolonged analgesia to patients having surgery using a lower abdominal transverse incision. Further research is needed, directly comparing the lateral with posterior approaches of the TAP block, to clarify whether or not the posterior approach provides superior prolonged analgesia.

Authors' contributions

F.W.A. helped design the study, conduct the study, analyse the data, and write the manuscript. F.W.A. is also the senior author and is responsible for archiving the study files. J.G.L. helped conduct the study, analyse the data, and write the manuscript. S.H.H. helped conduct the study, analyse the data, and write the manuscript. R.B. helped design the study, conduct the study, analyse the data, and write the manuscript.

Declaration of interest

None declared.

Funding

This work was supported by departmental funding. J.G.L. and R.B. were also supported by the Merit Award Program, Department of Anesthesia, University of Toronto.

References

1 Nygaard IE. Abdominal incisions from creation to closure. *Obstet Gynecol Surv* 1996; **51**: 429–36

2 Abu-Rustum NR. Radical abdominal hysterectomy. *Surg Clin North Am* 2001; **81**: 815–28

3 Angle P, Halpern S, Leighton B, Szalai JP, Gnanendran K, Kronberg J. A randomized controlled trial examining the effect of naproxen on analgesia during the second day after cesarean delivery. *Anesth Analg* 2002; **95**: 741–5

4 Gilron I, Orr E, Tu D, O'Neill JP, Zamora J, Bell A. A placebo-controlled randomized clinical trial of perioperative administration of gabapentin, rofecoxib and their combination for spontaneous and movement-evoked pain after abdominal hysterectomy. *Pain* 2005; **113**: 191–200

5 Fassoulaki A, Stamatakis E, Petropoulos G, Siafaka I, Hassiakos D, Sarantopoulos C. Gabapentin attenuates late but not acute pain after abdominal hysterectomy. *Eur J Anaesthesiol* 2006; **23**: 136–41

6 Lavand'homme P. From preemptive to preventive analgesia: time to reconsider the role of perioperative peripheral nerve blocks? *Reg Anesth Pain Med* 2011; **36**: 4–6

7 Nikolajsen LL. Chronic pain following caesarean section chronic pain after caesarean section. *Acta Anaesthesiol Scand* 2004; **48**: 111–6

8 Brandsborg B, Nikolajsen L, Kehlet H, Jensen TS. Chronic pain after hysterectomy. *Acta Anaesthesiol Scand* 2008; **52**: 327–31

9 Joris J, Cigarini I, Legrand M, *et al.* Metabolic and respiratory changes after cholecystectomy performed via laparotomy or laparoscopy. *Br J Anaesth* 1992; **69**: 341–5

10 Rafi AN. Abdominal field block: a new approach via the lumbar triangle. *Anaesthesia* 2001; **56**: 1024–6

11 Johns NN, O'Neill S, Ventham NT, Barron F, Brady RR, Daniel T. Clinical effectiveness of transversus abdominis plane (TAP) block in abdominal surgery: a systematic review and meta-analysis. *Colorectal Dis* 2012; **14**: 635–42

12 Abdallah FW, Chan VW, Brull R. Transversus abdominis plane block: the effects of surgery, dosing, technique, and timing on analgesic outcomes. A systematic review. *Reg Anesth Pain Med* 2012; **37**: 193–209

13 Patel SS. Transversus abdominis plane block for postoperative analgesia after cesarean delivery. *Matern Fetal Neonatal Med* 2012; **25**: 2270–3

14 McDonnell JG, Curley G, Carney J, *et al.* The analgesic efficacy of transversus abdominis plane block after cesarean delivery: a randomized controlled trial. *Anesth Analg* 2008; **106**: 186–91

15 Carney J, McDonnell JG, Ochana A, Bhinder R, Laffey JG. The transversus abdominis plane block provides effective postoperative analgesia in patients undergoing total abdominal hysterectomy. *Anesth Analg* 2008; **107**: 2056–60

16 Carney J, Finnerty O, Rauf J, Curley G, McDonnell JG, Laffey JG. Ipsilateral transversus abdominis plane block provides effective analgesia after appendectomy in children: a randomized controlled trial. *Anesth Analg* 2010; **111**: 998–1003

17 Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Int J Surg* 2010; **8**: 336–41

18 Lee TH, Barrington MJ, Tran TM, Wong D, Hebbard PD. Comparison of extent of sensory block following posterior and subcostal approaches to ultrasound-guided transversus abdominis plane block. *Anaesth Intensive Care* 2010; **38**: 452–60

19 Jadad AR, Moore RA, Carroll D, *et al.* Assessing the quality of reports of randomized clinical trials: is blinding necessary? *Control Clin Trials* 1996; **17**: 1–12

20 Canadian Pharmacists Association. *Compendium of Pharmaceuticals and Specialties: The Canadian Drug Reference for Health Professionals*, 45th Edn. Ottawa: Canadian Pharmacists Association, 2010

21 Higgins JP, Deeks JJ, Altman DG. Chapter 16: special topics in statistics. In: Higgins JP, Green S, eds. *Cochrane Handbook for Systematic Reviews of Interventions*. Baltimore, MD: The Cochrane Collaboration, 2011

22 Higgins JP. Quantifying heterogeneity in a meta-analysis. *Stat Med* 2002; **21**: 1539–58

23 Belavy D, Cowlishaw PJ, Howes M, Phillips F. Ultrasound-guided transversus abdominis plane block for analgesia after Caesarean delivery. *Br J Anaesth* 2009; **103**: 726–30

24 Costello JF, Moore AR, Wieczorek PM, Macarthur AJ, Balki M, Carvalho JC. The transversus abdominis plane block, when used as part of a multimodal regimen inclusive of intrathecal morphine, does not improve analgesia after cesarean delivery. *Reg Anesth Pain Med* 2009; **34**: 586–9

25 Baaj JM, Alsatli RA, Majaj HA, Babay ZA, Thallaj AK. Efficacy of ultrasound-guided transversus abdominis plane (TAP) block for postcesarean section delivery analgesia—a double-blind, placebo-controlled, randomized study. *Middle East J Anaesthesiol* 2010; **20**: 821–6

26 McMorrow RC, Ni Mhuircheartaigh RJ, Ahmed KA, *et al.* Comparison of transversus abdominis plane block vs spinal morphine for pain relief after caesarean section. *Br J Anaesth* 2011; **106**: 706–12

27 Amr YM, Amin SM. Comparative study between effect of pre- versus post-incisional transversus abdominis plane block on acute and chronic post-abdominal hysterectomy pain. *Anesth Essays Res* 2011; **5**: 77–82

28 Shin HJ. Preemptive analgesic efficacy of ultrasound-guided transversus abdominis plane block in patients undergoing gynecologic surgery via a transverse lower abdominal skin incision. *Korean J Anesthesiol* 2011; **61**: 413–8

29 Atim A, Bilgin F, Kilickaya O, *et al.* The efficacy of ultrasound-guided transversus abdominis plane block in patients undergoing hysterectomy. *Anaesth Intensive Care* 2011; **39**: 630–4

30 Tan TT. A randomised trial of the analgesic efficacy of ultrasound-guided transversus abdominis plane block after caesarean delivery under general anaesthesia. *Eur J Anaesthesiol* 2012; **29**: 88–94

31 Eslamian LL. Transversus abdominis plane block reduces postoperative pain intensity and analgesic consumption in elective cesarean delivery under general anesthesia. *J Anesth* 2012; **26**: 334–8

32 Bollag L, Richebe P, Siaulys M, Ortner CM, Gofeld M, Landau R. Effect of transversus abdominis plane block with and without clonidine on post-cesarean delivery wound hyperalgesia and pain. *Reg Anesth Pain Med* 2012; **37**: 508–14

33 Jankovic ZB, du Feu FM, McConnell P. An anatomical study of the transversus abdominis plane block: location of the lumbar triangle of Petit and adjacent nerves. *Anesth Analg* 2009; **109**: 981–5

34 Rozen WM, Tran TM, Ashton MW, Barrington MJ, Ivanusic JJ, Taylor GI. Refining the course of the thoracolumbar nerves: a new understanding of the innervation of the anterior abdominal wall. *Clin Anat* 2008; **21**: 325–33

35 Hebbard PD. Transversalis fascia plane block, a novel ultrasound-guided abdominal wall nerve block. *Can J Anaesth* 2009; **56**: 618–20

36 Hebbard P, Barrington M, Vasey C. Ultrasound-guided continuous oblique subcostal transversus abdominis plane blockade: description of anatomy and clinical technique. *Reg Anesth Pain Med* 2010; **35**: 436–41

37 Carney J, Finnerty O, Rauf J, Bergin D, Laffey J, Mc Donnell J. Studies on the spread of local anaesthetic solution in transversus abdominis plane blocks. *Anaesthesia* 2011; **66**: 1023–30

38 Finnerty O, McDonnell JG. Transversus abdominis plane block. *Curr Opin Anaesthesiol* 2012; **25**: 610–4

39 McDonnell JG, Finnerty O, Laffey JG. Stellate ganglion blockade for analgesia following upper limb surgery. *Anaesthesia* 2011; **66**: 611–4

40 Latzke D, Marhofer P, Kettner SC, *et al.* Pharmacokinetics of the local anesthetic ropivacaine after transversus abdominis plane block in healthy volunteers. *Eur J Clin Pharmacol* 2012; **68**: 419–25

41 Griffiths JD, Barron FA, Grant S, Bjorksten AR, Hebbard P, Royse CF. Plasma ropivacaine concentrations after ultrasound-guided transversus abdominis plane block. *Br J Anaesth* 2010; **105**: 853–6

42 Abrahams MS, Horn JL, Noles LM, Aziz MF. Evidence-based medicine: ultrasound guidance for truncal blocks. *Reg Anesth Pain Med* 2010; **35**: S36–42

43 Hebbard P, Fujiwara Y, Shibata Y, Royse C. Ultrasound-guided transversus abdominis plane (TAP) block. *Anaesth Intensive Care* 2007; **35**: 616–7

44 Factor D, Chin KJ. Transversus abdominis plane block in lower segment cesarean section: a question of block failure or lack of efficacy? *Reg Anesth Pain Med* 2010; **35**: 404–5

45 McDonnell JG, O'Donnell BD, Farrell T, *et al.* Transversus abdominis plane block: a cadaveric and radiological evaluation. *Reg Anesth Pain Med* 2007; **32**: 399–404

46 Weintraud M, Marhofer P, Bosenberg A, *et al.* Ilioinguinal/iliohypogastric blocks in children: where do we administer the local anesthetic without direct visualization? *Anesth Analg* 2008; **106**: 89–93

47 McGuirk SS. Use of invasive placebos in research on local anaesthetic interventions invasive placebos and local anaesthesia. *Anaesthesia* 2011; **66**: 84–91

Handling editor: R. P. Mahajan