British Journal of Anaesthesia **109** (5): 679–87 (2012)
Advance Access publication 19 August 2012 · doi:10.1093/bja/aes279

BJA

REVIEW ARTICLES

Transversus abdominis plane block for postoperative analgesia after Caesarean delivery performed under spinal anaesthesia? A systematic review and meta-analysis

F. W. Abdallah[1,2], S. H. Halpern[1,2,3] and C. B. Margarido[1,2,3]*

[1] Division of Obstetrical Anesthesia, Department of Anesthesia, Obstetrical Anesthesia Research Unit, Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada
[2] Department of Anaesthesia and Pain Management, Women's College Hospital, University of Toronto, Toronto, Ontario, Canada
[3] Obstetrical Anesthesia Research Unit, Sunnybrook Research Institute, Toronto, Ontario, Canada

* Corresponding author. E-mail: cmargarido@sunnybrook.ca

Editor's key points

- The utility of transversus abdominis plane (TAP) block in Caesarean delivery was assessed by analysing results of previous studies.
- TAP block reduced i.v. morphine consumption and pain scores in the first day after surgery.
- TAP block can provide effective analgesia after Caesarean delivery when intrathecal morphine has not been used.

Summary. The transversus abdominis plane (TAP) block is a field block that provides postoperative analgesia for abdominal surgery. Its analgesic utility after Caesarean delivery (CD) remains controversial. This systematic review and meta-analysis examines whether TAP block can reduce i.v. morphine consumption in the first 24 h after CD. The authors retrieved randomized controlled trials comparing TAP block with placebo in CD. Postoperative i.v. morphine consumption during the first 24 h was selected as a primary outcome. Pain scores and both maternal and neonatal opioid-related side-effects were secondary outcomes. Where possible, meta-analytic techniques and random effects modelling were used to combine data. Trials were stratified based on whether or not spinal morphine was used as part of the analgesic regimen. Five trials including 312 patients were identified. TAP block reduced the mean 24 h i.v. morphine consumption by 24 mg [95% confidence interval (CI) −39.65 to −7.78] when spinal morphine was not used. TAP block also reduced visual analogue scale pain scores (10 cm line where 0 cm, no pain, and 10 cm, worst pain) by 0.8 cm (95% CI −1.53 to −0.05, P=0.01), and decreased the incidence of opioid-related side-effects. The differences in primary and secondary outcomes were not significant when spinal morphine was used. TAP block provides superior analgesia compared with placebo and can reduce the first 24 h morphine consumption in the setting of a multimodal analgesic regimen that excludes spinal morphine. TAP block can provide effective analgesia when spinal morphine is contraindicated or not used.

Keywords: acute pain, novel techniques; anaesthesia, obstetric; anaesthetic blocks, regional; analgesia, postoperative; regional blockade

Inadequate postoperative pain relief after Caesarean delivery (CD) can negatively impact ambulation, breastfeeding, and even maternal bonding,[1] while effective analgesia improves the amount of breastfeeding and infant weight gain.[2] Neuraxial anaesthesia has become the anaesthetic technique of choice in CD because of its safety and reduction in maternal mortality.[3]

The transversus abdominis plane (TAP) block, a field block[4] whose analgesic efficacy in several abdominal surgeries has been confirmed,[5–7] has also been proposed for postoperative analgesia in parturients undergoing elective CD under spinal anaesthesia.[8] However, the analgesic utility of TAP block remains controversial; some trials comparing it with placebo reported significant advantages,[8 9] while others found no analgesic benefit.[10 11] Reviews examining the analgesic effects of TAP block in various surgeries have not provided definitive answers regarding the specific role of TAP block in CD. A Cochrane review examining the efficacy of TAP block in abdominal surgeries excluded CD.[12] A recent meta-analysis supporting TAP block for its effective pain relief included only one trial in the setting of CD.[13] A 2012 qualitative systematic review[14] examined the role of TAP block across all abdominal surgeries and raised questions about its role in the setting of multimodal analgesia but stopped short of conducting any further analysis specific to CD. The purpose of this systematic review was to determine whether or not TAP block is effective in providing pain relief after CD. The primary outcome was morphine consumption in the first 24 h, an important issue for the breastfeeding woman.

Methods

The authors followed the PRISMA[15] recommendations in preparing this review.

Eligibility criteria

We searched the literature for randomized controlled trials (RCTs) that compared TAP block with placebo in patients undergoing elective CD under spinal anaesthesia. We included trials that used both ultrasound and landmark guidance for the single-shot TAP block technique.

Literature search

RCTs were retrieved from the US National Library of Medicine database, MEDLINE; the Excerpta Medica database, EMBASE; Cochrane Database of Systematic Reviews; Cochrane Central Register of Controlled Trials; and Latin American and Caribbean Health Sciences Literature, LILACS databases. The search terms TAP, TAP block, transversus abdominis, transverse abdominis, transversus abdominis plane block, transversus abdominis block, transverse abdominis plane block, transverse abdominis block, Caesarean, and C section were used in combination with the medical subject headings nerve block/abdomen/abdominal cavity/abdominal wall/abdominal muscles, and Caesarean Section (January 2007–February 2012).

In addition, we searched the bibliographies of relevant reviews and identified RCTs that fulfilled the inclusion criteria. We also searched for and reviewed published abstracts of anaesthesiology meetings that were held during the period 2007–2012 by the American Society of Anesthesiologists, the American Society of Regional Anesthesia, the Society of Obstetric Anesthesia and Perinatology, the European Society of Anaesthesiology, and the European Society of Regional Anaesthesia. Finally, we sought unpublished data at 'clinicaltrials.gov' as a measure of publication bias. No language restriction was used. The final list of qualifying studies was derived by consensus among the three authors. Excluded trials are listed in the Appendix.

Data collection and presentation

Quality of the reviewed trials was assessed independently by two of the authors (F.W.A. and C.B.M.) using the Cochrane Risk of Bias tool.[16] A final score was assigned for each trial by consensus. I.V. morphine consumption during the first 24 h after CD was defined as a primary outcome. Rest and dynamic pain visual analogue scale (VAS) scores (10 cm unmarked line in which 0 cm, no pain, and 10 cm, worst pain imaginable) at 24 h and maternal opioid-related side-effects (sedation, pruritus, nausea, and vomiting), patient satisfaction, and block-related complications were designated as secondary outcomes. A standardized data collection form was used for outcome data extraction. Data were recorded independently by two of the authors (F.W.A., C.B.M.) to avoid transcription errors; discrepancies were resolved by re-inspection of the original data.

Meta-analysis

The data were then entered into the statistical program (by C.B.M.) and rechecked (by F.W.A.). When possible, meta-analytic techniques (Revman 5.1, Cochrane Library, Oxford, UK) were used to combine the data. Random effect modelling was used in analysing continuous and dichotomous outcomes. The standardized mean difference and 95% confidence interval (CI) were calculated for continuous outcomes; while odds ratio (OR) and 95% CI were calculated for dichotomous outcomes. Differences were considered statistically significant when the 95% CI did not include 0. The I^2 statistic was used to assess heterogeneity.[17]

As the analgesic efficacy of spinal morphine in postoperative pain control is well recognized,[18–20] we hypothesized—*a priori*—that it constitutes a co-intervention that would generate significant heterogeneity among the pooled trial results. We therefore performed subgroup analysis according to administration of intrathecal morphine (ITM), where (SM−) referred to the group of RCTs where spinal morphine was not used, while (SM+) referred to the group of RCTs where spinal morphine was used.

Results

Search results, including retrieved, excluded, and reviewed RCTs, are summarized by a flowchart in Figure 1. We found five trials[5 8–11] with a total of 312 patients that met the inclusion criteria. The trials reviewed included one[11] where TAP block and placebo were compared in the presence and absence of spinal morphine, resulting in two distinct comparisons. Table 1 summarizes trial characteristics and the outcomes sought in each of the reviewed trials. The methodological quality of the included studies and the risk of bias are described in Table 2; Table 3 defines the analgesic regimens used in the reviewed trials. In addition to the published studies, we found five unpublished studies at 'clinicaltrials.gov' comprising 438 patients who potentially meet the inclusion criteria but were still in the recruitment phase.

Postoperative morphine consumption

Postoperative i.v. morphine consumption during the first 24 h in each study and pooled consumption are shown in Figure 2. When spinal morphine is excluded from the multimodal analgesic regimen (SM−), we found that TAP block, compared with placebo, reduced the mean 24 h i.v. morphine consumption by 24 mg (95% CI −39.65 to −7.78). This statistically significant reduction (P=0.004) favours TAP block. When both groups received spinal morphine (SM+), TAP block did not significantly reduce morphine consumption (mean difference 2 mg, 95% CI −3.47 to 7.46, P=0.47). The pooled morphine consumption of the SM+ and SM− subgroups was lower by 15 mg (95% CI −33.10 to 2.56) in patients receiving TAP block, although this lacked statistical significance (P=0.09). Heterogeneity among the studies in the SM− subgroup and in the pooled studies was significant (I^2=0.94 and 0.97, respectively, P<0.00001).

Rest pain scores

The 24 h rest VAS scores for individual and pooled studies are shown in Figure 3. Compared with placebo in the (SM−) setting, TAP block reduced 24 h rest VAS scores by 0.8 cm

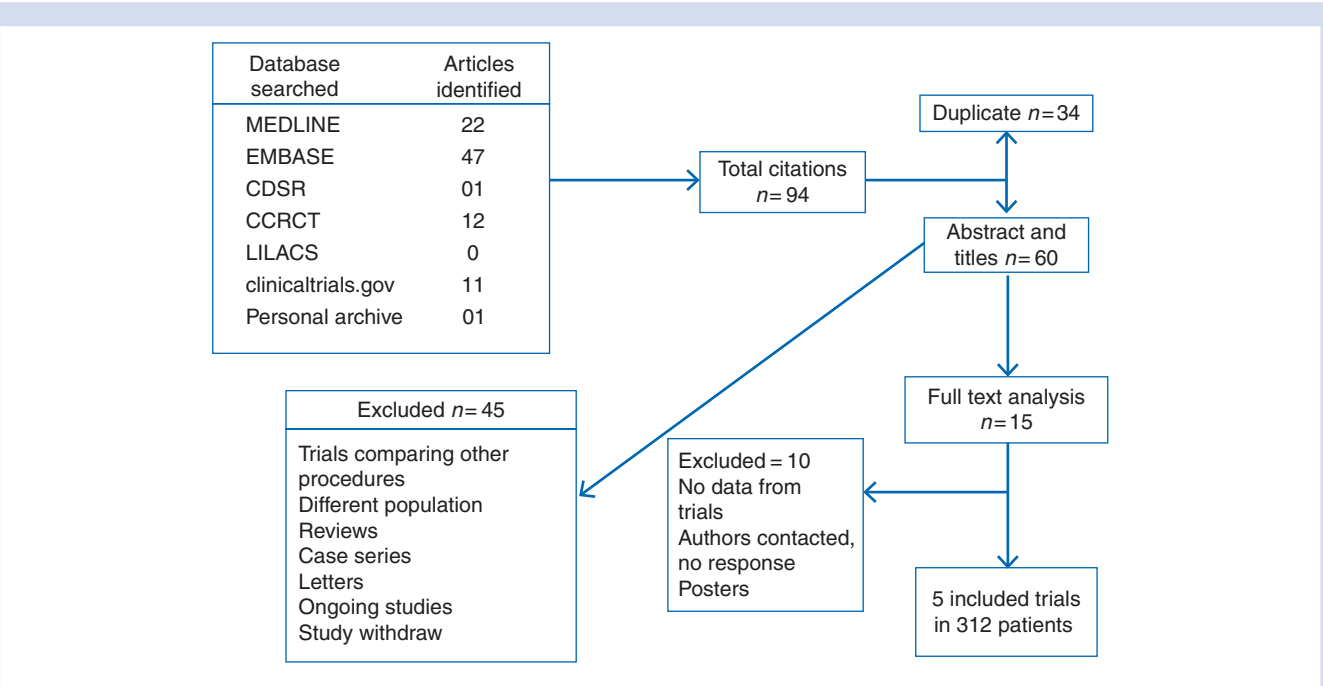

Fig 1 Flowchart summarizing retrieved, included, and excluded RCTs. MEDLINE, US National Library of Medicine; EMBASE, Excerpta Medica database; CDSR, Cochrane Database of Systematic Reviews; CCRCT, Cochrane Central Register of Controlled Trials; LILACS, Latin American and Caribbean Health Sciences Literature.

(95% CI −1.53 to −0.05, P=0.01). The difference was not significant in the SM+ group (0.3 cm, 95% CI −0.42 to 0.97, P=0.08). The pooled difference favoured TAP block but was not statistically significant (P=0.39). Heterogeneity was significant in both SM− and SM+ subgroups (I^2=0.72; P=0.01 and I^2=0.67; P=0.08, respectively).

Dynamic pain scores

Figure 4 shows the 24 h dynamic VAS scores for individual and pooled studies. Difference between the groups were not statistically significant for either the SM− or the SM+ studies.

Opioid-related side-effects

The reviewed trials were inconsistent in reporting opioid-related side-effects. Four trials reported the incidence of postoperative nausea and vomiting (PONV);[5 8 9 11] while three reported the incidence of sedation,[5 8 11] and another two reported the incidence of pruritus.[5 11] The inconsistency in reporting these outcomes and the heterogeneity of assessment when these outcomes were reported precludes quantitative analysis. Qualitative analysis of trials in the (SM−) subgroup showed that all of the trials[5 8 9 11] that assessed the incidence of PONV reported reduced incidence in patients who received TAP block. Furthermore, one[8] of the three[5 8 11] trials that assessed sedation showed reduced incidence with TAP block, while two[5 11] showed no difference. As for pruritus, one trial[5] showed no difference, while another[11] showed reduced incidence with TAP block.

Opioid-related side-effects assessment in the (SM+) group was performed in only one trial; the incidence of pruritus favoured TAP block, while the incidence of PONV favoured control group.[11] Neonatal opioid-related side-effects of TAP block such as somnolence and difficulty with breastfeeding were not studied in any of the trials.

There was no reported difference in the incidence of chronic pain in the single trial that assessed this outcome.[10] TAP block resulted in improved patient satisfaction in two trials[5 9] and reduced satisfaction in one.[11] Three of the trials[5 9 10] reviewed examined block-related complications, but none was reported.

Discussion

This review suggests that TAP block constitutes an effective analgesic option capable of reducing 24 h opioid consumption, 24 h rest pain scores, and PONV in parturients undergoing CD who receive a multimodal analgesic regimen that excludes ITM. While the improvement in pain scores was modest and not clinically relevant, the difference in i.v. morphine consumption was robust and clinically significant. These differences are not significant in the presence of ITM. It should be noted that heterogeneity in baseline morphine consumption among the studies might have significantly contributed to the difference between the (SM+) and (SM−) groups. There were insufficient data to conclude that TAP affects the incidence of other opioid-related side-effects such as sedation or pruritus.

Reduction in opioid analgesics is generally desirable in CD and more so when spinal morphine is not used. Although

Table 1 Trial characteristics and reported outcomes. ITM, intrathecal morphine; TAP, transversus abdominis plane

Study	*n*	Groups (*n*)	Primary outcome	Rest pain scores	Dynamic pain scores	Opioid consumption	Time to first analgesic request	Opioid-related adverse effects	Patient satisfaction	Block-related complications	Chronic pain
McDonnell and colleagues[8]	52	1. TAP block (25)	Opioid consumption	•	•	•	•	•			
		2. Sham block (25)									
Belavy and colleagues[5]	50	1. TAP block (23)	Opioid consumption	•	•	•	•	•	•	•	
		2. Sham block (24)									
Costello and colleagues[10]	100	1. TAP block (49)	Dynamic pain scores	•	•	•			•	•	•
		2. Sham block (47)									
Baaj and colleagues[9]	40	1. TAP block (19)	Opioid consumption	•	•	•		•	•	•	
		2. Sham block (20)									
McMorrow and colleagues[11]	80	1. TAP block+ITM (20)	Dynamic pain scores	•	•	•		•	•		
		2. Sham TAP+ITM (20)									
		3. TAP block (20)									
		4. Sham block (20)									

opioid analgesics can be taken safely by lactating women, some opioids can result in significant exposures and toxicity in infants,[21] including the risk of neurobehavioural depression in the breastfed newborn.[22] Future research is needed to examine the ability of TAP block to reduce opioid metabolites in infant plasma.

As a component of spinal anaesthesia, the superiority of post-Caesarean analgesia produced by long-acting spinal opioids over their systemic counterparts[18 19] makes them an integral part of multimodal analgesic regimens.[20 23 24] Since neuraxial anaesthesia has been established as the best modality for CD, it has become difficult to justify excluding a small dose of ITM,[25]given the superior analgesia it produces, the prolonged duration of this analgesia,[26–28] and its ability to treat both somatic[20] and visceral[29–31] components of pain.

The absence of definitive analgesic advantages of TAP block when added to multimodal analgesic regimens inclusive of ITM,[10 11] and its inferiority, as a substitute to ITM demonstrated in three recent trials,[11 32 33] suggest a potential role of TAP block as part of the post-Caesarean multimodal analgesic regimen in practice settings that do not use long-acting intrathecal opioids or when their use is either not feasible or contraindicated. There is also recent evidence to suggest that TAP block might be beneficial for patients undergoing CD under general anaesthesia.[34 35]

Although not studied, TAP block might be useful when other components of multimodal analgesia such as non-steroidal anti-inflammatory drugs (NSAIDs) are contraindicated. Patients with conditions such as hypersensitivity to NSAIDs, renal impairment, concomitant use of nephrotoxic drugs, or a history of peptic ulcer disease might benefit from TAP block as a practical alternative for pain relief.

This review is limited by the small size of included studies and the significant heterogeneity in reporting the primary and secondary outcomes. Our sample comprised 312 patients; however, there are five unpublished trials with 438 patients reported at 'clinicaltrials.gov' for which we have no data. This represents a significant risk of publication bias (Appendix). Also, some important outcomes were missing in all trials reviewed, such as differentiation between visceral and somatic pain, effect of TAP block on breastfeeding, and its effect on the incidence of chronic pain after CD. Further limitations include differences in TAP block technique and doses of local anaesthetics used. In the absence of dose-ranging studies that assess the impact of various volumes and concentrations of local anaesthetics on post-Caesarean analgesia produced by TAP block, and since the studies reviewed did not assess patients for the presence of sensory block, we cannot ascertain the success of TAP blocks performed. Additionally, our choice to combine ultrasound-guided and landmark-guided TAP blocks might be challenged by recent evidence that indicates differences between the two techniques. Anatomically guided TAP blocks performed in the triangle of Petit can produce prolonged analgesia, and theoretically less morphine consumption, compared with their

Table 2 Risk of bias. Each study risk of bias was assessed using the Cochrane Collaboration tool[16] as Low (low risk of bias), High (high risk of bias), or Unclear for each question-based entry

Study	Adequate sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete data addressed	Free of selective reporting
McDonnell and colleagues[8]	Low	Low	Low	Low	Low	Low
Belavy and colleagues[5]	Low	Unclear	Low	Low	Low	Low
Costello and colleagues[10]	Low	Unclear	Unclear	Low	Low	Low
Baaj and colleagues[9]	Unclear	Unclear	Low	Low	Low	Low
McMorrow and colleagues[11]	Unclear	Low	Low	Low	Low	Low

Table 3 Analgesic regimens used in included trials. *Volume refers to injection per side. I.V. PCA, i.v. patient-controlled analgesia

Study	Surgical analgesia	Supplemental postoperative analgesia	TAP block	
			Localization	Block solution*
McDonnell and colleagues[8]	Spinal+intrathecal: 25 μg fentanyl	1 dose rectal diclofenac, 1 dose rectal acetaminophen, then i.v. PCA morphine, oral acetaminophen, rectal diclofenac	Anatomical	1.5 mg kg^{-1} 0.75% ropivacaine to a total dose of 150 mg
Belavy and colleagues[5]	Spinal+intrathecal: 15 μg fentanyl	1 dose rectal acetaminophen, 1 dose rectal diclofenac, then i.v. PCA morphine, oral acetaminophen, oral ibuprofen	Ultrasound	20 ml 0.5% ropivacaine
Costello and colleagues[10]	Spinal+intrathecal: 10 μg fentanyl, 100 μg morphine	1 dose i.v. ketorolac, 1 dose rectal acetaminophen, then i.v. morphine, oral diclofenac, oral acetaminophen	Ultrasound	20 ml 0.375% ropivacaine
Baaj and colleagues[9]	Spinal+intrathecal: 20 μg fentanyl	I.V. PCA morphine	Ultrasound	20 ml 0.25% bupivacaine
McMorrow and colleagues[11]	Spinal+intrathecal: 10 μg fentanyl, 100 μg morphine	1 dose rectal acetaminophen, 1 dose rectal diclofenac, then i.v. PCA morphine, oral acetaminophen, rectal diclofenac	Anatomical	1 mg kg^{-1} 0.375% bupivacaine

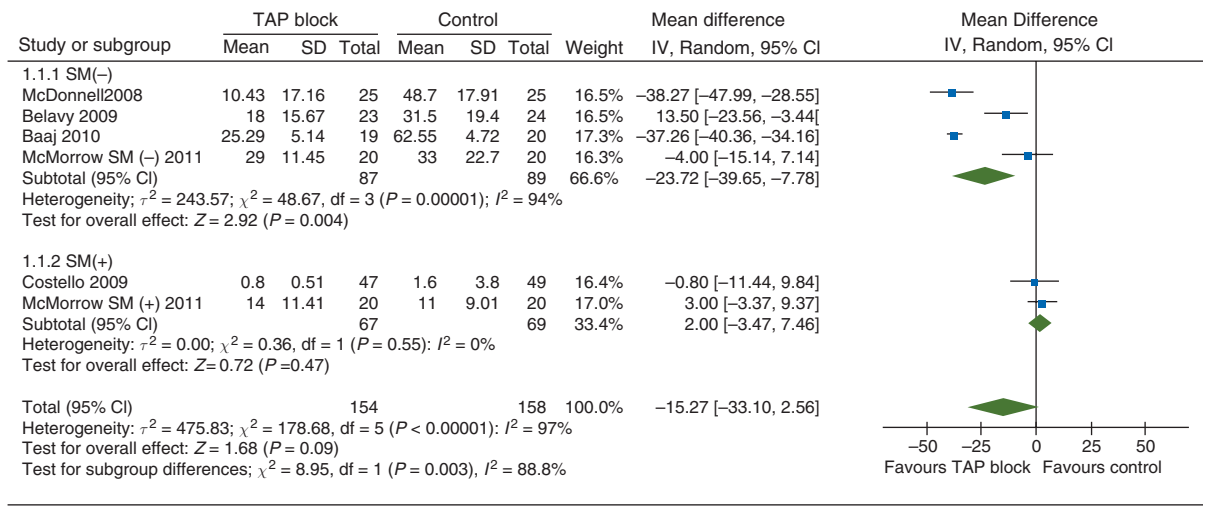

Fig 2 Forest plot showing the 24 h morphine consumption. The sample size, mean, standard deviations (SDs), and pooled estimates of mean difference are shown. The 95% CIs are shown as lines for individual studies and as diamonds for pooled estimates. SM, spinal morphine.

ultrasound-guided counterparts,[14] an observation that can be attributed to paravertebral spread.[36] There is evidence to suggest that only a small fraction of landmark-guided blocks deposit local anaesthetics in the correct anatomical plane,[37] thus rendering their analgesic efficacy questionable. Finally, the authors wish to underscore the ethical concern

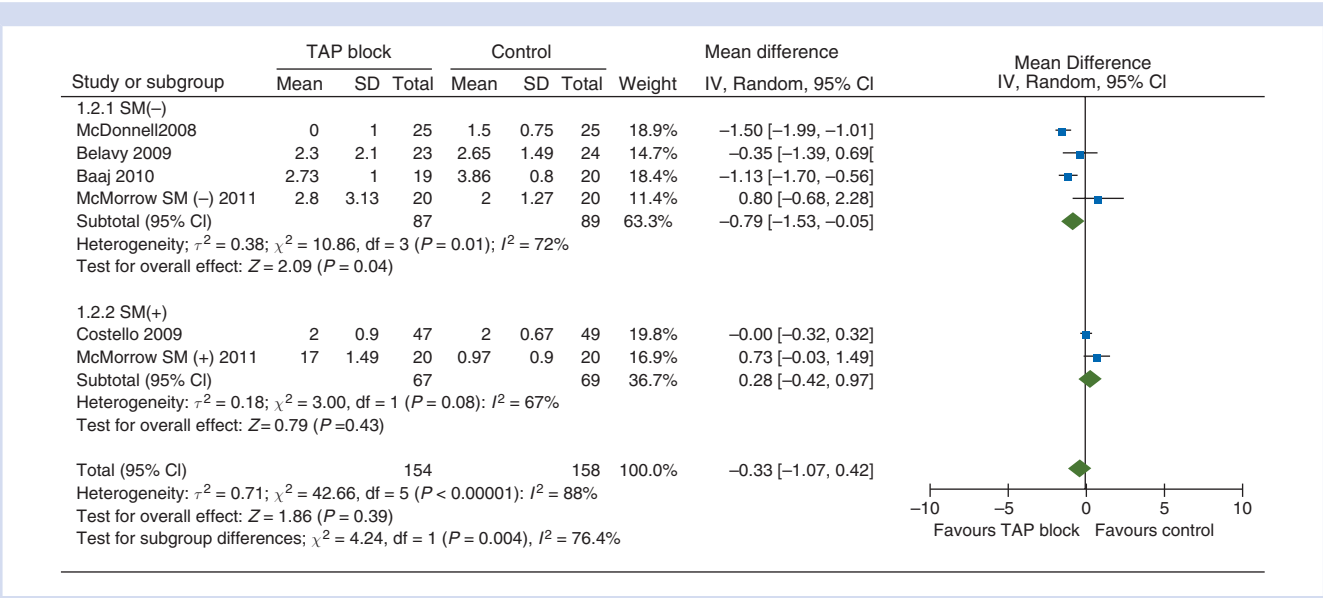

Fig 3 Forest plot showing the 24 h rest VAS pain scores. The sample size, mean, standard deviations (SDS), and pooled estimates of mean difference are shown. The 95% CIs are shown as lines for individual studies and as diamonds for pooled estimates. SM, spinal morphine.

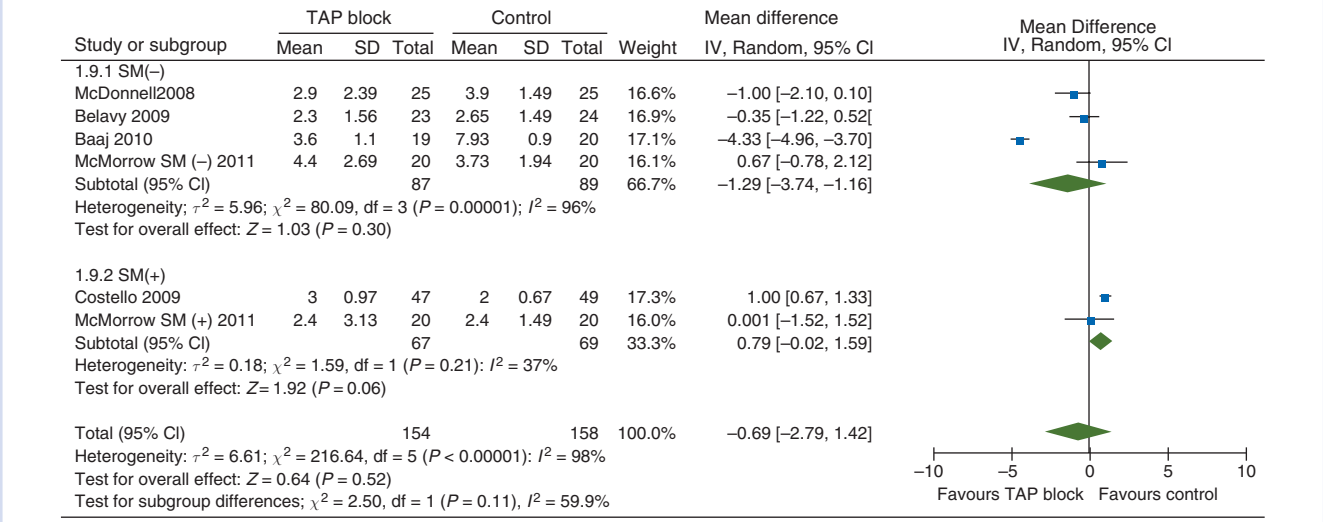

Fig 4 Forest plot showing the 24 h dynamic VAS pain scores. The sample size, mean, standard deviations (SDS), and pooled estimates of mean difference are shown. The 95% CIs are shown as lines for individual studies and as diamonds for pooled estimates. SM, spinal morphine.

that arises from potential harm associated with the use of invasive placebo[38 39] in the reviewed trials. Patients in the control groups in all five trials received a saline injection in the TAP, a practice classified as Grade 4 on the scale of serious harm and morbidity (SHAM) as it might predispose parturients to risks similar to those associated with local anaesthetic injection.[40 41]

In summary, TAP block constitutes an effective analgesic option for postoperative analgesia after CD performed under spinal anaesthesia when spinal morphine is not used. There is currently no evidence that the TAP block is of benefit when ITM has been administered.

Acknowledgement

We thank Henry Lam, librarian and information specialist of the Department of Library Services of Sunnybrook Hospital.

Declaration of interest

None declared.

Funding

This work was supported by departmental funding.

Appendix: Excluded studies

First author	Reference	Reason for exclusion
Bamigboye	*Cochrane Database Syst Rev* 2009;**8**:CD006954	Design: review
Bogra	*BMC Anesthesiol* 2005;**5**:5	Inappropriate intervention
Bollag	www.clinicaltrials.gov	In progress, no data available
Bonnet	*Br J Anaesth* 2009;**103**:468–70	Design: editorial
Cambic	www.clinicaltrials.gov	In progress, no data available
Canovas	*Eur J Pain* 2011;**5**:99	Poster, authors contacted
Costello	*Reg Anesth Pain Med* 2009;**34**:586–9	Inappropriate intervention
Cowlishaw	*Reg Anesth Pain Med* 2009;**34**:183	Inappropriate population
Edwards	*Int J Obstet Anesth* 2009;**18**:S42	Design: cohort
Eslamian (1)	www.clinicaltrials.gov	In progress, no data available
Eslamian (2)	www.clinicaltrials.gov	In progress, no data available
Factor	*Reg Anesth Pain Med* 2010;**35**:404–5	Design: case report
Fischler	www.clinicaltrials.gov	In progress, no data available
French	*Int J Obstet Anesth* 2009;**18**:52–4	Design: case report
Frenk	www.clinicaltrials.gov	In progress, no data available
Ghosn	*Eur J Pain* 2011;**5**:270–1	Inappropriate comparator
Gogarten	*Eur J Anaesthesiol* 2004;**21**:38–45	Inappropriate intervention
Hart	www.clinicaltrials.gov	In progress, no data available
Hebbard	*Anaesth Intensive Care* 2007;**35**:617–8	Design: audit
Hebbard	*Reg Anesth Pain Med* 2010;**35**:324	Design: letter
Hoydonckx	*Reg Anesth Pain Med* 2010;**35**:E45	Inappropriate comparator
Isaacs	*Int J Obstet Anesth* 2010;**19**:468–9	Design: letter
Jayakumar	*Trends Anaesth Crit Care* 2011;**1**:128–34	Design: review
Joshi	*Anaesthesia* 2002;**57**:515–7	Inappropriate population
Kanazi	*Anesth Analg* 2010;**111**:475–81	Inappropriate comparator
Kearns	*Int J Obstet Anesth* 2010;**19**:S41	Design: survey
Kerai	*J Obstet Anaesth Crit Care* 2011;**1**:30–4	Inappropriate comparator
Kishore	*J Anaesthesiol Clin Pharmacol* 2011;**27**:336–8	Inappropriate population
Kuppuvelumani	*Asia Oceania J Obstet Gynaecol* 1993;**19**:165–9	Inappropriate intervention
Lefort	*Acta Anaesthesiol Scand* 2010;**54**:1155	Design: case report
Loos	*Ann Surg* 2008;**248**:880–5	Inappropriate intervention
Masters	*Paediatr Anaesth* 2011;**21**:87–8	Design: letter
McKeen	www.clinicaltrials.gov	In progress, no data available
Mei	*Anesth Analg* 2011;**113**:134–7	Design: case series
Morton	*Int J Obstet Anesth* 2010;**19**:S7	Design: audit
Mostafa	*Egypt J Anaesth* 2004;**20**:155–60	Inappropriate intervention
Ngamprasertwong	*J Med Assoc Thai* 2005;**88**:1563–8	Inappropriate intervention
Owen	*Br J Obstet Gyneacol* 2011;**118**:24–7	Design: case series
Pan	*Int J Obstet Anesth* 2004;**13**:227–33	Design: retrospective
Patel	*Am J Obstet Gynecol* 2012;**206**:S135	Design: letter
Petersen	*Acta Anaesthesiol Scand* 2010;**54**:529–35	Design: review
Preston	www.clinicaltrials.gov	Inappropriate comparator
Puddy	*Anaesthesia* 2010;**65**: 95	Design: letter
Randall	*Anesth Analg* 2008;**106**:1928	Design: case report
Riddell	*Reg Anesth Pain Med* 2010;**35**:E162–3	Design: survey
Scharine	*AANA J* 2009;**77**:98–102	Design: case report
Shah	*Reg Anesth Pain Med* 2010;**35**:E142	Design: observational
Siddiqui	*J Clin Anesth* 2011;**23**:7–14	Design: review
Silva	*Can J Anaesth* 2010;**57**:S96	Design: non-blinded
Soliman	*Tech Reg Anaesth Pain Manage* 2009;**13**:117–20	Design: review
Tan	*Reg Anesth Pain Med* 2010;**35**:E56	Inappropriate intervention
Urbanczak	*Anestezjol Intens Ter* 2009;**41**:166–9	Design: review
Vandendriessche	*Acta Anaesthesiol Belg* 2010;**61**:107	Inappropriate comparator
Wenstrom	*Obstet Gynecol Surv* 2008;**63**:295–7	Design: letter

References

1 Leung A. Postoperative pain management in obstetric anesthesia—new challenges and solutions. *J Clin Anesth* 2004; **16**: 57–65

2 Hirose M, Hara Y, Hosokawa T, Tanaka Y. The effect of postoperative analgesia with continuous epidural bupivacaine after cesarean section on the amount of breast feeding and infant weight gain. *Anesth Analg* 1996; **82**: 1166–9

3 Hawkins JL, Koonin LM, Palmer SK, Gibbs CP. Anesthesia-related deaths during obstetric delivery in the united states, 1979–1990. *Anesthesiology* 1997; **86**: 277–84

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

5 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

6 Niraj G, Searle A, Mathews M, *et al.* Analgesic efficacy of ultrasound-guided transversus abdominis plane block in patients undergoing open appendicectomy. *Br J Anaesth* 2009; **103**: 601–5

7 El-Dawlatly AA, Turkistani A, Kettner SC, *et al.* Ultrasound-guided transversus abdominis plane block: description of a new technique and comparison with conventional systemic analgesia during laparoscopic cholecystectomy. *Br J Anaesth* 2009; **102**: 763–7

8 McDonnell J, 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

9 Baaj J, Alsatli R, Majaj H, Babay Z, Thallaj A. 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

10 Costello J, Moore A, Wieczorek P, Macarthur A, Balki M, Carvalho JCA. 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

11 McMorrow RCN, 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

12 Charlton S, Cyna AM, Middleton P, Griffiths JD. Perioperative transversus abdominis plane (TAP) blocks for analgesia after abdominal surgery. *Cochrane Database Syst Rev* 2010; **12**: 007705

13 Siddiqui MRS, Sajid MS, Uncles DR, Cheek L, Baig MK. A meta-analysis on the clinical effectiveness of transversus abdominis plane block. *J Clin Anesth* 2011; **23**: 7–14

14 Abdallah FW, Brull R. Transversus abdominis plane block: a systematic review. *Reg Anesth Pain Med* 2012; **37**: 193

15 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

16 Higgins JPT. The Cochrane collaboration's tool for assessing risk of bias in randomised trials. *Br Med J (Clin Res Ed.)* 2011; **343**: d5928

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

18 Dahl JB, Jeppesen IS, Jrgensen H, Wetterslev J, Miniche S. Intraoperative and postoperative analgesic efficacy and adverse effects of intrathecal opioids in patients undergoing cesarean section with spinal anesthesia: a qualitative and quantitative systematic review of randomized controlled trials. *Anesthesiology* 1999; **91**: 1919–27

19 Gwirtz KH, Young JV, Byers RS, *et al.* The safety and efficacy of intrathecal opioid analgesia for acute postoperative pain: seven years' experience with 5969 surgical patients at Indiana University Hospital. *Anesth Analg* 1999; **88**: 599–604

20 Gadsden J, Hart S, Santos A. Post-cesarean delivery analgesia. *Anesth Analg* 2005; **101**: S62–9

21 Ito S, Lee A. Drug excretion into breast milk—overview. *Adv Drug Deliv Rev* 2003; **55**: 617–27

22 Wittels B, Glosten B, Faure EA, *et al.* Postcesarean analgesia with both epidural morphine and intravenous patient-controlled analgesia: neurobehavioral outcomes among nursing neonates. *Anesth Analg* 1997; **85**: 600–6

23 McDonnell NJ, Keating ML, Muchatuta NA, Pavy TJG, Paech MJ. Analgesia after caesarean delivery. *Anaesth Intensive Care* 2009; **37**: 539–51

24 Pan P. Post cesarean delivery pain management: multimodal approach. *Int J Obstet Anesth* 2006; **15**: 185–8

25 Gehling M, Tryba M. Risks and side-effects of intrathecal morphine combined with spinal anaesthesia: a meta-analysis. *Anaesthesia* 2009; **64**: 643–51

26 Chadwick HS, Ready LB. Intrathecal and epidural morphine sulfate for post-cesarean analgesia—a clinical comparison. *Anesthesiology* 1988; **68**: 925–9

27 Gehling MHG, Luesebrink T, Kulka PJ, Tryba M. The effective duration of analgesia after intrathecal morphine in patients without additional opioid analgesia: a randomized double-blind multicentre study on orthopaedic patients. *Eur J Anaesthesiol* 2009; **26**: 683–8

28 Meylan N, Elia N, Lysakowski C, Tramr MR. Benefit and risk of intrathecal morphine without local anaesthetic in patients undergoing major surgery: meta-analysis of randomized trials. *Br J Anaesth* 2009; **102**: 156–67

29 Omote K, Kawamata M, Iwasaki H, Namiki A. Effects of morphine on neuronal and behavioural responses to visceral and somatic nociception at the level of spinal cord. *Acta Anaesthesiol Scand* 1994; **38**: 514–7

30 Scott PV, Bowen FE, Cartwright P, *et al.* Intrathecal morphine as sole analgesic during labour. *Br Med J* 1980; **281**: 351–3

31 Tong C, Conklin D, Eisenach J. A pain model after gynecologic surgery: the effect of intrathecal and systemic morphine. *Anesth Analg* 2006; **103**: 1288–93

32 Kanazi G, Aouad M, Abdallah F, *et al.* The analgesic efficacy of subarachnoid morphine in comparison with ultrasound-guided transversus abdominis plane block after cesarean delivery: a randomized controlled trial. *Anesth Analg* 2010; **111**: 475–81

33 Loane HH. A randomized controlled trial comparing intrathecal morphine with transversus abdominis plane block for post-cesarean delivery analgesia. *Int J Obstet Anesth* 2012; **21**: 112–8

34 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

35 Tan TT, Teoh WH, Woo DC, Ocampo CE, Shah MK, Sia AT. 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

36 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

37 McDermott G, Korba E, Mata U, *et al.* Should we stop doing blind transversus abdominis plane blocks? *Br J Anaesth* 2012; **108**: 499–502

38 McGuirk S, Fahy C, Costi D, Cyna AM. Use of invasive placebos in research on local anaesthetic interventions. *Anaesthesia* 2011; **66**: 84–91

39 Jarman J, Marks N, Fahy CJ, Costi D, Cyna AM. Anaesthetists' risk assessment of placebo nerve block studies using the SHAM (serious harm and morbidity) scale. *Anaesthesia* 2012; **67**: 361–6

40 Lancaster P, Chadwick M. Liver trauma secondary to ultrasound-guided transversus abdominis plane block. *Br J Anaesth* 2010; **104**: 509–10

41 Farooq M, Carey M. A case of liver trauma with a blunt regional anesthesia needle while performing transversus abdominis plane block. *Reg Anesth Pain Med* 2008; **33**: 274–5