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OBSTETRICS

Comparison of transversus abdominis plane block *vs* spinal morphine for pain relief after Caesarean section

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Editor's key points

- Transversus abdominis plane (TAP) blocks are increasingly used for analgesia after abdominal surgery.
- This study assessed whether TAP blocks provide additional analgesia to spinal morphine after Caesarean section.
- Pain scores and analgesia requirements were lowest in those receiving spinal morphine 100 μg.
- Bilateral TAP blocks using bupivacaine 2 mg kg^{-1} had no extra analgesic effects.

Background. Transversus abdominis plane (TAP) block is an alternative to spinal morphine for analgesia after Caesarean section but there are few data on its comparative efficacy. We compared the analgesic efficacy of the TAP block with and without spinal morphine after Caesarean section in a prospective, randomized, double-blinded placebo-controlled trial.

Methods. Eighty patients were randomized to one of four groups to receive (in addition to spinal anaesthesia) either spinal morphine 100 μg (S_M) or saline (S_S) and a postoperative bilateral TAP block with either bupivacaine (T_{LA}) 2 mg kg^{-1} or saline (T_S).

Results. Pain on movement and early morphine consumption were lowest in groups receiving spinal morphine and was not improved by TAP block. The rank order of median pain scores on movement at 6 h was: S_MT_{LA} (20 mm)<S_MT_S (27.5 mm)<S_ST_S (51.5 mm)<S_ST_{LA} (52.0 mm) ($P<0.05$, highest *vs* lowest). The rank order of median morphine consumption at 6 h was: S_MT_S (4.0 mg)<S_MT_{LA} (5.0 mg)<S_ST_{LA} (8.0 mg)<S_ST_S (12.0 mg) and at 24 h was: S_MT_{LA} (5.0 mg)<S_MT_S (6.0 mg)<S_ST_S (9.5 mg)<S_ST_{LA} (15.0 mg) ($P<0.05$, highest *vs* lowest). Sedation scores and patient satisfaction did not differ between groups. Anti-emetic use and pruritus were highest in the S_MT_{LA} group.

Conclusions. Spinal morphine—but not TAP block—improved analgesia after Caesarean section. The addition of TAP block with bupivacaine 2 mg kg^{-1} to spinal morphine did not further improve analgesia.

Keywords: anaesthesia, spinal; anaesthesia regional; bupivacaine; Caesarean section; morphine; nerve block; pain, postoperative

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Caesarean section is one of the most commonly performed surgical procedures. It is estimated that 15% of births worldwide and 21.1% of those in the developed world occur by Caesarean section.[1] Caesarean rates of up to 31.9% have been reported in the UK in 2008[2] and over 1 million are thought to be carried out annually in the USA alone.[3] The optimum form of postoperative analgesia is not known, but many procedures are carried out under spinal anaesthesia and patients typically receive spinal, systemic, or both opioids as components of multimodal analgesia in the postoperative period. However, opioids, whether given via the spinal or systemic route, are frequently associated with adverse effects such as nausea, pruritus, sedation, and occasionally respiratory depression.[4] It has been recommended recently that patients should be monitored extensively to detect respiratory depression[5] after receiving hydrophilic opioids via the spinal route. Thus, knowledge about alternative (non-opioid) analgesia is important.

The transversus abdominis plane (TAP) block is a regional analgesic technique which blocks T6–L1 nerve branches and has an evolving role in postoperative analgesia for lower abdominal surgeries.[6–8] It is a simple and safe technique and is a potential alterative to spinal opioid for analgesia after Caesarean section, whether guided by traditional anatomic landmarks or by ultrasound.[9–12] It has been shown to be effective in Caesarean section and after hysterectomy, open prostatectomy, laparoscopic cholecystectomy, and appendicectomy.[13–16] However, there are few studies comparing TAP block with spinal opioids or with epidural analgesia.[17] If superior to spinal opioids, TAP block would have the advantage of improved analgesia, a reduction in opioid-associated adverse effects, and the absence of motor blockade. Furthermore, local anaesthetic-based techniques may provide comparable resting analgesia but superior analgesia on movement compared with systemic opioids and may be synergistic with neuraxial opioids.

Therefore, we performed a prospective study to compare the relative analgesic efficacy of TAP block with local anaesthetic to spinal morphine after Caesarean section. Our aims were (i) to determine the analgesic efficacy of TAP block, (ii) to compare TAP block to spinal morphine, and (iii) to determine whether a TAP block, when administered in addition to spinal morphine, provided any incremental benefit. We hypothesized that a TAP block with local anaesthetic would result in less pain on movement than spinal morphine at 6 h after operation.

Methods

After approval by the hospital ethics committee, the Irish Medicine Board, and written informed consent, we studied 80 ASA physical status I–III subjects undergoing elective Caesarean delivery, in a prospective double-blind placebo-controlled clinical trial. Patients were excluded if there was a history of relevant drug allergy, tolerance to opiates, BMI>35 kg m^{-2} at initial hospital visit, pre-eclampsia, or contraindication to neuraxial anaesthesia.

Patients received a standard spinal anaesthetic comprising hyperbaric bupivacaine 11–12.5 mg with fentanyl 10 μg and were randomized using sealed envelopes to one of four groups (n=20 in each group) to a combination of spinal morphine (S_M) or saline (S_S) with TAP block containing local anaesthetic (T_{LA}) or saline (T_S), as follows: S_MT_S, S_MT_{LA}, S_ST_{LA}, or S_ST_S.

Patients also received preservative-free spinal morphine 100 μg (SNS Pharmaceuticals, London) or an equivalent volume (0.l ml) of saline, co-administered with the spinal anaesthetic. Bilateral TAP blockade was performed with bupivacaine 2 mg kg^{-2} (based on weight at first presentation to hospital), equivalent volume of 0.9% saline, or both (Table 1).

The volume of 0.375% bupivacaine to be injected on each side to provide a total dose of 2 mg kg^{-1} solution was calculated by the following formula:

$$\text{Volume per syringe (ml)} = \frac{\text{weight (kg)}}{3.75}$$

The group allocation information was given in a sealed envelope to the pharmacist who delivered the study drugs to the operating theatre in a sealed package labelled with the subject name and number. All staff providing direct care and the subjects were blinded to the group assignment.

All subjects received standard monitoring including electrocardiogram, non-invasive arterial pressure, and arterial oxygen saturation. All subjects received rectal paracetamol 1 g and diclofenac 100 mg immediately after operation. Each patient received bilateral TAP blocks in the operating theatre immediately after completion of surgery by one of two investigators (R.C.N.McM. and J.P.R.L.). The bilateral TAP blocks were performed with an 18 G Tuohy needle (80 mm Smiths Medical Portex®; BS6196) using the mid-axillary landmark technique as described by McDonnell and colleagues.[11]

All patients were prescribed a standard postoperative analgesic regime of regular oral paracetamol 1 g 6 hourly, rectal diclofenac 100 mg 18 hourly and morphine via patient-controlled analgesia (PCA): 1 mg bolus with a 5 min lockout through a dedicated i.v. line. Prochlorperazine 12.5 mg i.m. was prescribed for nausea or vomiting as required.

The primary outcome was pain on movement, defined as elevation of the head and shoulders from the pillow, in the supine position. Secondary outcomes were pain at rest, morphine consumption, the proportion of patients who achieved adequate analgesia,[18] satisfaction, sedation, nausea, and pruritus. Patients were assessed at 6, 12, 24, 36, and 48 h after TAP block. At the 6, 24, and 48 h reviews, subjects were assessed for pain, satisfaction, nausea, sedation, pruritus, and morphine use. At each of the three assessments, patients were asked to record their average pain at rest and on moving over the previous 6, 18, and 24 h, respectively, covering the period between assessments on an ungraduated 100 mm visual analogue scale with 'none' and 'worst imaginable' at the extremes. They were then asked to rate their overall satisfaction with the quality of their postoperative pain relief over the same time period on a centre marked but otherwise ungraduated 100 mm visual analogue scale with 'extremely dissatisfied' and 'extremely satisfied' at the extremes; the centre mark was labelled 'neither'. Patients' nausea and pruritus was rated using a categorical scale (0, none; 1, mild; 2, moderate; and 3, severe). A sedation score was assigned by the assessor using a sedation scale (1, awake and alert; 2, slightly drowsy, easily roused; 3, drowsy, drifts off to sleep during conversation; and 4, somnolent, minimal, or no response to physical stimulation). Requirement for anti-emetics was also noted.

Using data from a previous audit of morphine use after Caesarean delivery in our hospital, we determined that a study with 16 subjects in each of four arms would have a 90% power to detect a mean reduction in pain score (scale 0–100 mm) of 40 mm with an SD of 29 mm. To allow for drop outs, we recruited an additional four patients per group.

Statistical analyses were performed using Sigma Stat (Version 2.0; Jandel Corporation, San Rafael, CA, USA). Normally distributed data were analysed by one-way analysis of variance. Categorical data were analysed using the χ^2 or Fisher's exact test. Non-parametric data were compared with ANOVA on ranks. Planned intergroup comparisons were made with the Student–Newman–Keuls or the Dunn method. Normally distributed data are presented as mean (SD). Data which did not fit a normal distribution are presented as median [inter-quartile range (IQR)]. The α level for analyses was set as $P \leq 0.05$. Correction for multiple comparisons was made using the Bonferroni method where appropriate.

Table 1 Group allocation and treatment. S_M, spinal morphine; S_S, spinal saline; T_S, transversus abdominis plane block with saline; T_{LA}, transversus abdominis plane block with local anaesthetic

Group	Spinal	TAP	n
S_MT_S	Morphine 100 μg	Saline	20
S_MT_{LA}	Morphine 100 μg	Bupivacaine 2 mg kg^{-1}	20
S_ST_{LA}	Saline	Bupivacaine 2 mg kg^{-1}	20
S_ST_S (control)	Saline	Saline	20

Table 2 Patient characteristics. Continuous data are presented as mean (SD) or median (IQR). There were no statistical differences between groups. S_M, spinal morphine; S_S, spinal saline; T_{LA}, transversus abdominis plane block with local anaesthetic; T_S, transversus abdominis plane block with saline

Group	S_MT_S (n=20)	S_MT_{LA} (n=20)	S_ST_{LA} (n=20)	S_ST_S (n=20)
Age (yr)	33 (4)	34 (6)	33 (5)	34 (5)
Gestation (wks)	39 (1)	39 (1)	38 (2)	39 (2)
Parity	1 (1–2)	1 (1–2)	1 (1–1)	1 (0–1)
ASA	1 (1–1)	1 (1–1)	1 (1–1)	1 (1–1)
Booking Weight (kg)	70 (13)	74 (14)	72 (14)	66 (15)
Height (cm)	162 (7)	161 (5)	166 (6)	162 (6)
BMI (kg m^{-2})	27 (4)	28 (5)	26 (5)	25 (5)
TAP Volume	19 (4)	20 (4)	19 (4)	18 (4)

Results

Eighty subjects entered the study. All patients who entered randomization completed the study. There were no differences in age, gestation, parity, ASA grade, booking weight, height, BMI, or volume of TAP injectate received between the groups (Table 2). Early morphine consumption and pain on movement were lowest in groups receiving spinal morphine and was not improved by the addition of a TAP block.

Pain scores

The rank order of median pain scores on movement was as follows (P<0.05, highest *vs* lowest):

- 6 h: S_MT_{LA} (20 mm)<S_MT_S (27.5 mm)<S_ST_S (51.5 mm)<S_ST_{LA} (52.0 mm).

At 24 and 48 h, there was no difference among the groups (Fig. 1).

The rank order of median pain scores at rest was as follows (Fig. 2; P<0.05, highest *vs* lowest):

- 6 h: S_MT_{LA} (8.5 mm)<S_MT_S (16 mm)<S_ST_S (29 mm)<S_ST_{LA} (31 mm).
- 24 h: S_MT_S (10 mm)<S_MT_{LA} (12 mm)=S_ST_S (20 mm)<S_ST_{LA} (26.5 mm).

At 48 h, there was no difference among the groups (Fig. 2).

Morphine consumption

The rank order of median morphine consumption was as follows (Fig. 3; P<0.05, highest *vs* lowest at each time):

- 6 h: S_MT_S (4.0 mg)<S_MT_{LA} (5.0 mg)<S_ST_{LA} (8.0 mg)<S_ST_S (12.0 mg).
- 12 h: S_MT_S (2.0 mg)<S_MT_{LA} (5.0 mg)<S_ST_S (6.0 mg)<S_ST_{LA} (10.5 mg).
- 24 h: S_MT_{LA} (5.0 mg)<S_MT_S (6.0 mg)<S_ST_S (9.5 mg)<S_ST_{LA} (15.0 mg).

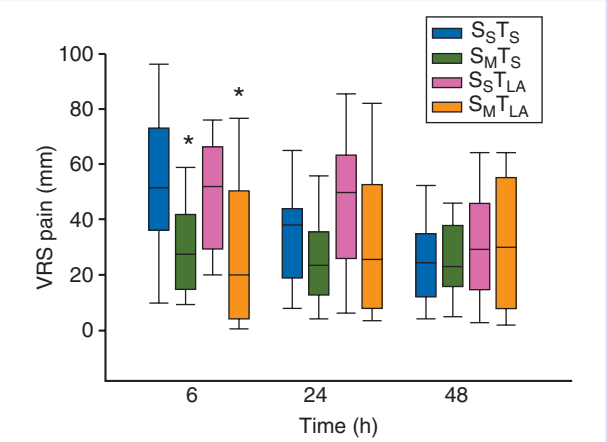

Fig 1 Pain scores on movement. S_M, spinal morphine; S_S, spinal saline; T_{LA}, transversus abdominis plane block with local anaesthetic; T_S, transversus abdominis plane block with saline. *P<0.05 *vs* S_ST_S.

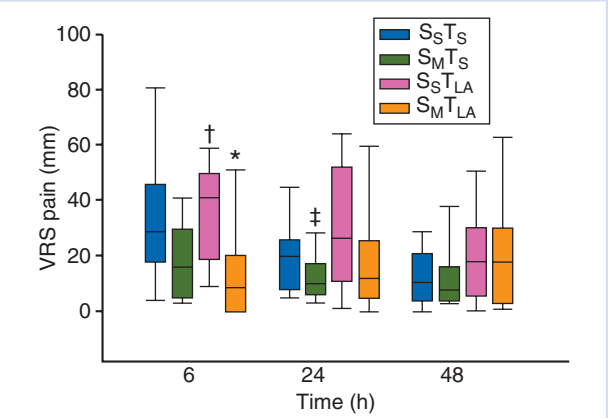

Fig 2 Pain scores at rest. S_M, spinal morphine; S_S, spinal saline; T_{LA}, transversus abdominis plane block with local anaesthetic; T_S, transversus abdominis plane block with saline. *P<0.05 *vs* S_ST_S; †P<0.05 *vs* S_MT_{LA}; ‡P<0.05 *vs* S_ST_{LA}.

There was no among-group difference in interval morphine consumption from 36 to 48 h (Fig. 3).

Proportion of patients who achieved adequate analgesia

The rank order of the proportion of patients who achieved a visual rating scale (VRS) score of <30 mm at rest was as follows:

- 6 h: S_MT_{LA} (90%)>S_MT_S (80%)>S_ST_S (55%)>S_ST_S (45%) (P=0.007, highest *vs* lowest) (Fig. 4).
- 24 h: S_MT_S (95%)>S_ST_S (90%)>S_MT_{LA} (80%)>S_ST_{LA} (60%) (P=0.02, highest *vs* lowest) (Fig. 4).

There was no difference in the proportion of patients who achieved VAS<30 mm (rest) at 48 h (Fig. 4).

The rank order of the proportion of patients who achieved a VRS score of <30 mm on movement was as follows:

- 6 h: S_MT_S (65%)>S_MT_{LA} (60%)>S_ST_{LA} (25%)>S_ST_S(15%) (P=0.004, highest *vs* lowest).

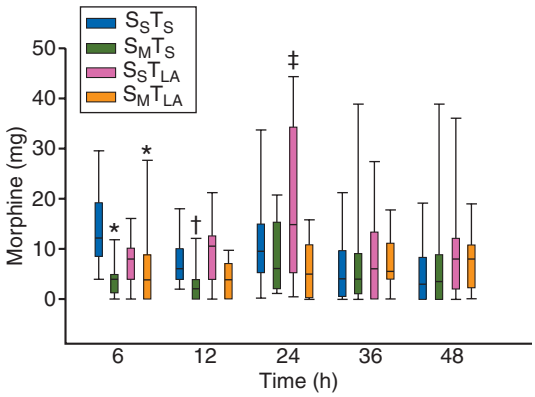

Fig 3 Interval morphine consumption. S_M, spinal morphine; S_S, spinal saline; T_{LA}, transversus abdominis plane block with local anaesthetic; T_S, transversus abdominis plane block with saline. *P<0.05 *vs* S_ST_S. †P<0.05 *vs* S_ST_{LA}. ‡P<0.05 *vs* S_MT_{LA}.

There was no difference in the proportion of patients who achieved VAS<30 mm (movement) at 24 or 48 h (Fig. 4).

Adverse effects and satisfaction

Sedation scores were not different between the groups (data not shown). No patient experienced category 4 sedation (somnolence) and only one patient in the study experienced category 3 sedation (drowsy). Patient satisfaction was not different between groups (Table 3). The highest use of anti-emetics was seen in the S_MT_{LA} group in the first 6 h (Table 3). Moderate pruritus was most common in the S_MT_S group (Table 4).

Discussion

The aims of this study were to determine the efficacy of TAP block, to compare TAP block to spinal morphine, and to determine whether any incremental benefit was obtained from their combination in patients undergoing Caesarean section. We found an analgesic benefit with spinal morphine but no analgesic effect of the TAP block. No additional analgesic benefit was observed when TAP and spinal morphine were administered in combination. Pruritus was more common in patients receiving spinal morphine. Patient satisfaction was equivalent in all groups.

In previous placebo-controlled trials, a clear analgesic benefit of both spinal morphine and TAP block has been demonstrated but no comparative data for spinal morphine and TAP block have been published. Our data are in contrast

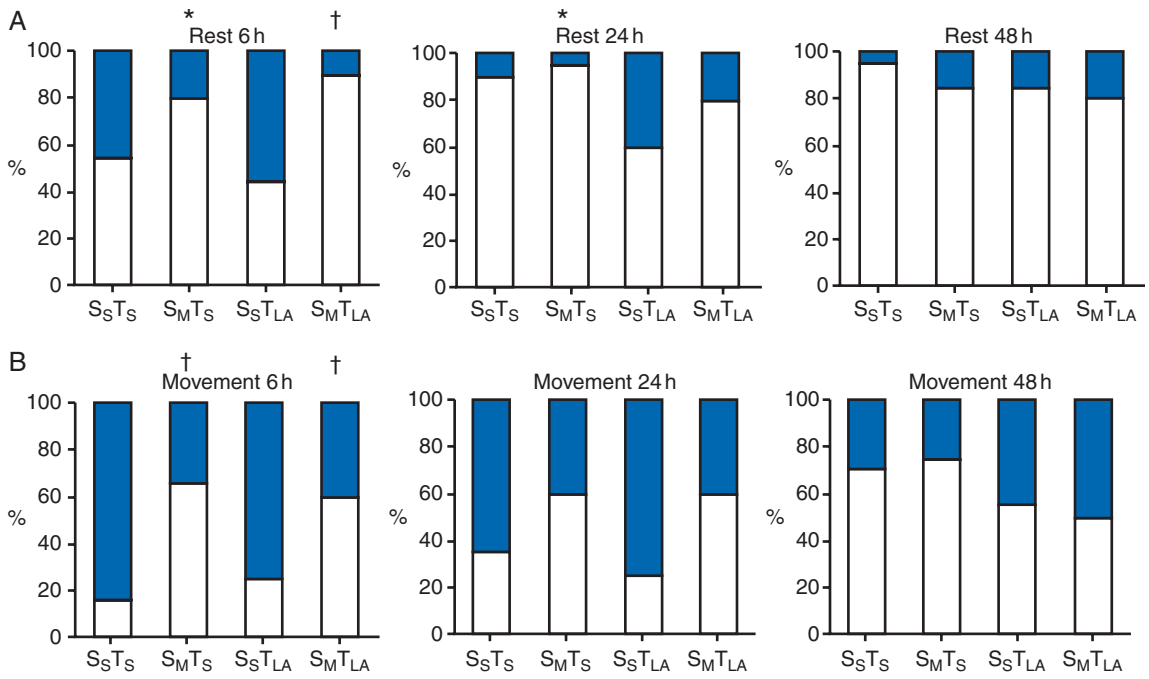

Fig 4 Proportion of patients achieving adequate analgesia. (A) Pain at rest. (B) Pain on movement. S_M, spinal morphine; S_S, spinal saline; T_{LA}, transversus abdominis plane block with local anaesthetic; T_S, transversus abdominis plane block with saline. *P<0.05 *vs* S_ST_{LA}. †P<0.05 *vs* S_ST_S.

Table 3 Patient satisfaction and anti-emetic use. Patient satisfaction data are median (IQR). Anti-emetic use data are number (*n*). S_M, spinal morphine; S_S, spinal saline; T_{LA}, transversus abdominis plane block with local anaesthetic; T_S, transversus abdominis plane block with saline. *$P<0.05$ *vs* S_ST_S, S_ST_{LA}

	S_ST_S ($n=20$)	S_MT_S ($n=20$)	S_ST_{LA} ($n=20$)	S_MT_{LA} ($n=20$)
Patient satisfaction				
6 h	62 (32.5–84.5)	89.0 (73.0–94.5)	76.0 (61.5–92.5)	90.5 (56.0–98.5)
24 h	76.0 (51.5–86.0)	83.5 (72.0–88.5)	76.0 (52.0–94.5)	72.5 (29.5–93.5)
48 h	86.0 (79.0–95.0)	85.5 (59.0–92.0)	79.5 (68.5–96.0)	87.5 (66.5–96.5)
Anti-emetic use				
6 h	0	2	0	5*
24 h	4	3	2	4
48 h	0	3	1	2

Table 4 Pruritus. Data are number (*n*). S_M, spinal morphine; S_S, spinal saline; T_{LA}, transversus abdominis plane block with local anaesthetic; T_S, transversus abdominis plane block with saline. *$P<0.05$ *vs* S_ST_S, S_MT_S, S_ST_{LA}. †$P<0.05$ *vs* S_ST_{LA}

Pruritus	S_ST_S ($n=20$)	S_MT_S ($n=20$)	S_ST_{LA} ($n=20$)	S_MT_{LA} ($n=20$)
6 h				
None (*n*, %)	11	11	13	4*
Mild (*n*, %)	7	7	3	13†
Moderate (*n*, %)	2	2	3	2
Severe (*n*, %)	0	0	0	1
24 h				
None (*n*, %)	11	11	5	7
Mild (*n*, %)	4	4	10	9
Moderate (*n*, %)	3	3	3	4
Severe (*n*, %)	1	1	2	0
48 h				
None (*n*, %)	14	14	13	11
Mild (*n*, %)	3	3	3	4
Moderate (*n*, %)	2	2	3	1
Severe (*n*, %)	1	0	0	2

to those of previous investigators who reported an analgesic benefit of TAP blockade in patients undergoing a wide variety of lower abdominal surgery,[12 14–16] but are consistent with those of Costello and colleagues.[10] These investigators found no analgesic benefit from TAP block performed using ultrasound (with ropivacaine 20 ml 0.375% per side) in patients undergoing Caesarean section under spinal anaesthesia with morphine 100 μg.[10] As spinal morphine was used in both study groups, no direct comparison of TAP to spinal morphine was possible. Belavy and colleagues[9] also investigated the effect of TAP block with ropivacaine 0.5% 20 ml each side in patients undergoing Caesarean section, but without spinal morphine. Postoperative opioid consumption was reduced for the first six postoperative hours and cumulative opioid consumption at 24 h was reduced in the active group,[9] although no adjustment was made for multiple comparisons for secondary outcomes.[9]

The reasons for the differences in outcome between our study and those previously described are unclear. First, although our blocks were performed by only two operators, both previously experienced in the technique and who used the palpation technique as recommended, the medications differed. We used bupivacaine 2 mg kg^{-1} of 0.375% solution in a volume of 0.26 ml kg^{-1} per side, whereas McDonnell and colleagues used a total of 3 mg kg^{-1} of ropivacaine in a volume of 0.2 ml kg^{-1} per side. Volume of local anaesthetic has been suggested to be important in determining the spread of TAP block but dose–response studies of drug amount and concentration have not been performed. Secondly, unlike the previous series by McDonnell, in our study, the operator was fully blinded to the investigative medications. Also our study population was slightly different: we excluded parturients who had a BMI of >35 mg kg^{-1} at booking, and we used less fentanyl (10 *vs* 25 μg) in the spinal anaesthetic. Spinal fentanyl has previously been shown to exert greater duration of analgesia with increasing doses.[19] Furthermore, we assessed the patients at different time points to previous studies and also we did not use ultrasound for TAP block placement. It is likely that distribution of local anaesthetic is different between the two approaches as ultrasonically guided blocks are placed more anteriorly where the sonoanatomy is more clearly defined, whereas paravertebral spread is more likely with the mid-axillary approach.[20–23] We opted not to use ultrasound for the study as the mid-axillary point corresponding to earlier studies has ill-defined sonoanatomy and the wider applicability of the landmark technique-merited study. Finally, TAP block was administered at the completion of surgery, whereas spinal morphine was administered approximately an hour earlier in conjunction with the spinal local anaesthetic. However, this is unlikely to have influenced pain scores at 6 h, the first time point in the study.

There are several limitations of this study. We did not seek to demonstrate loss of dermatomal sensation which would have demonstrated a successful block, for fear of loss of blinding and the introduction of bias. TAP as performed in this study is a tactile procedure, and as we did not use ultrasound to visualize the anatomy, we cannot guarantee correct

placement of the block. It is therefore possible that a portion of our blocks were placed incorrectly, either superficially or intraperitoneally.[22 24] Despite attempts at blinding to reduce bias, the pharmacological effects of the study medications, for example, nausea or itch in patients who received spinal morphine or loss of abdominal wall sensation in TAP blocks, may allow both investigator and patient to be able to deduce group allocation. All patients in the study received spinal fentanyl, which produces an early onset of analgesia, although this may have largely waned by 6 h after operation.

It is noteworthy that the current benchmark recommendation[18] that 90% of patients should achieve a postoperative visual analogue score of 30 mm was not attained in any of the study groups in terms of pain on movement, despite a regular paracetamol, diclofenac, and access to i.v. PCA morphine (Fig. 4). Despite the early analgesia seen in the morphine groups, this approach to analgesia has some limitations, namely an analgesic ceiling in doses in excess of 0.2 mg and increased side-effects[25] and it did not increase patient satisfaction in our study. Multimodal analgesia in association with any of our study interventions did not achieve consistently adequate levels of analgesia.

We conclude that in the setting of multimodal analgesia, spinal morphine reduces early pain after Caesarean section. TAP block does not provide comparable analgesia and does not provide additional benefit to spinal morphine. Therefore, TAP block as described in the study is of no therapeutic value for patients administered alone or in combination with spinal morphine. Additional studies using ultrasound and different drug combinations and doses of local anaesthetic for TAP block are warranted.

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Conflict of interest

None declared.

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References

1 Betran AP, Merialdi M, Lauer JA, *et al.* Rates of caesarean section: analysis of global, regional and national estimates. *Paediatr Perinat Epidemiol* 2007; **21**: 98–113

2 Bragg F, Cromwell DA, Edozien LC, *et al.* Variation in rates of caesarean section among English NHS trusts after accounting for maternal and clinical risk: cross sectional study. *Br Med J* 2010; **341**: c5065

3 Mathai M, Hofmeyr GJ. Abdominal surgical incisions for caesarean section. *Cochrane Database Syst Rev* 2007; CD004453

4 Madadi P, Ross CJ, Hayden MR, *et al.* Pharmacogenetics of neonatal opioid toxicity following maternal use of codeine during breastfeeding: a case–control study. *Clin Pharmacol Ther* 2009; **85**: 31–5

5 Horlocker TT, Burton AW, Connis RT, *et al.* Practice guidelines for the prevention, detection, and management of respiratory depression associated with neuraxial opioid administration. *Anesthesiology* 2009; **110**: 218–30

6 Marhofer P, Harrop-Griffiths W, Willschke H, Kirchmair L. Fifteen years of ultrasound guidance in regional anaesthesia: Part 2-recent developments in block techniques. *Br J Anaesth* 2010; **104**: 673–83

7 Bonnet F, Berger J, Aveline C. Transversus abdominis plane block: what is its role in postoperative analgesia? *Br J Anaesth* 2009; **103**: 468–70

8 Petersen PL, Mathiesen O, Torup H, Dahl JB. The transversus abdominis plane block: a valuable option for postoperative analgesia? A topical review. *Acta Anaesthesiol Scand* 2010; **54**: 529–35

9 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

10 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

11 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

12 McDonnell JG, Laffey JG. Transversus abdominis plane block. *Anesth Analg* 2007; **105**: 883

13 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

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 McDonnell JG, O'Donnell B, Curley G, Heffernan A, Power C, Laffey JG. The analgesic efficacy of transversus abdominis plane block after abdominal surgery: a prospective randomized controlled trial. *Anesth Analg* 2007; **104**: 193–7

16 Niraj G, Kelkar A, Fox AJ. Oblique sub-costal transversus abdominis plane (TAP) catheters: an alternative to epidural analgesia after upper abdominal surgery. *Anaesthesia* 2009; **64**: 1137–40

17 Tornero-Campello G. Transversus abdominis plane block should be compared with epidural for postoperative analgesia after abdominal surgery. *Anesth Analg* 2007; **105**: 281–2; author reply 2–3

18 Collins SL, Moore RA, McQuay HJ. The visual analogue pain intensity scale: what is moderate pain in millimetres? *Pain* 1997; **72**: 95–7

19 Belzarena SD. Clinical effects of intrathecally administered fentanyl in patients undergoing cesarean section. *Anesth Analg* 1992; **74**: 653–7

20 Tran TM, Ivanusic JJ, Hebbard P, Barrington MJ. Determination of spread of injectate after ultrasound-guided transversus abdominis plane block: a cadaveric study. *Br J Anaesth* 2009; **102**: 123–7

21 Barrington MJ, Ivanusic JJ, Rozen WM, Hebbard P. Spread of injectate after ultrasound-guided subcostal transversus abdominis plane block: a cadaveric study. *Anaesthesia* 2009; **64**: 745–50

22 Jankovic Z, Ahmad N, Ravishankar N, Archer F. Transversus abdominis plane block: how safe is it? *Anesth Analg* 2008; **107**: 1758–9

23 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

24 Pasqualucci A, de Angelis V, Contardo R, *et al.* Preemptive analgesia: intraperitoneal local anesthetic in laparoscopic cholecystectomy. A randomized, double-blind, placebo-controlled study. *Anesthesiology* 1996; **85**: 11–20

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