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Ultrasound-guided transversus abdominis plane block for analgesia after Caesarean delivery

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Background. The landmark-guided transversus abdominis plane (TAP) block is an effective method of providing postoperative analgesia in patients undergoing lower abdominal surgery. We evaluated the analgesic efficacy of the ultrasound (US)-guided TAP block in patients undergoing Caesarean delivery.

Methods. A randomized, double-blind, placebo-controlled trial was performed at a tertiary maternity hospital. Fifty women undergoing Caesarean delivery received bilateral US-guided TAP blocks with either ropivacaine 0.5% or saline. All participants received a spinal anaesthetic with bupivacaine and fentanyl, followed by postoperative acetaminophen, non-steroidal anti-inflammatory drugs, and patient-controlled i.v. morphine without long-acting intrathecal opioids. Each patient was assessed 24 h after delivery for morphine usage, average pain score, nausea, vomiting, pruritus, drowsiness, and satisfaction with pain relief.

Results. Forty-seven participants completed the trial, 23 in the active group and 24 in the placebo group. Total morphine use in 24 h was reduced in the active group (median 18.0 mg) compared with the placebo group (median 31.5 mg, $P<0.05$). The active group reported improved satisfaction with their pain relief measured by visual analogue scale compared with the placebo group (median 96 *vs* 77 mm, $P=0.008$). Fewer patients required antiemetics in the active group ($P=0.03$). There were no local complications attributable to the TAP block, but one participant had an anaphylactoid reaction after ropivacaine injection.

Conclusions. The US-guided TAP block reduces morphine requirements after Caesarean delivery when used as a component of a multimodal analgesic regimen.

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Women having a Caesarean delivery present a unique set of challenges to the anaesthetist after operation. These motivated women want to be alert, comfortable, and mobile in order to care for their baby. As part of a multimodal analgesic regimen, opioids are required initially to achieve effective analgesia. However, opioids are associated with dose-dependent side-effects including nausea, vomiting, pruritus, sedation, and respiratory depression. Techniques that reduce opioid requirements may be of benefit in this population.

McDonnell and colleagues[1 2] demonstrated that the transversus abdominis plane (TAP) block reduces morphine use after abdominal surgery, including Caesarean delivery. The block described is a landmark-guided technique. It requires the detection of two pops, or loss of resistance, using a short-bevel needle to locate the facial

layer between the internal oblique and the transversus abdominis muscles. Cadaver dissection confirms the presence of the T10 to L1 thoracolumbar nerves in this fascial layer.[3] Injection of local anaesthetic into this plane can anaesthetize the lower abdominal wall.

Since McDonnell and colleagues[1 2] published their trials, liver injury and intraperitoneal injection have been reported after landmark-guided TAP blocks.[4 5] An ultrasound (US) guided approach to the TAP block has been described.[6] US guidance offers the advantage of direct visualization of the needle and of the placement of local anaesthetic, which might improve safety and efficacy.

The purpose of this study was to assess the analgesic efficacy of an US-guided TAP block. We hypothesized that an US-guided TAP block performed after Caesarean delivery would reduce patient-controlled analgesia (PCA) morphine consumption in the first 24 h after operation as part of a multimodal analgesic regimen without the use of long-acting intrathecal opioids.

Methods

The trial was approved by the Mater Health Service Human Research and Ethics Committee and registered with the Australia and New Zealand Clinical Trials Registry (ACTRN12608000540314). We studied 50 ASA I and II women having Caesarean deliveries at term in a randomized, double-blind, placebo-controlled trial. All participants were 18 yr or older and gave informed consent. Exclusions from the trial included regular opioid use, a BMI >35 (at the time of enrolment), and a pre-pregnancy weight <50 kg (to limit the maximum ropivacaine dose to 4 mg kg^{-1}).

All participants received spinal anaesthesia using hyperbaric 0.5% bupivacaine 11 mg and fentanyl 15 μg. Participants were permitted to have combined spinal–epidural techniques but were excluded if the epidural was used during the case. Intraoperative antiemetics were not routinely administered, but if required, ondansetron 4 mg i.v. was first line.

An US-guided TAP block was performed at the end of surgery. The injectate syringes were prepared by the hospital pharmacy under aseptic conditions. Syringes contained either saline 40 ml (placebo group) or ropivacaine 0.5% (40 ml) (AstraZeneca Pty Ltd, North Ryde, NSW, Australia; active group). The group allocation of syringes was according to a block randomization table and unknown to the investigators.

The US-guided TAP block technique was similar to the method described by Hebbard and colleagues.[6] A 38 mm linear array US probe (13-6 MHz) was positioned in the mid-axillary line in the axial plane half-way between the iliac crest and the costal margin. Views were considered satisfactory, if s.c. fat, external oblique muscle, internal oblique muscle, transversus abdominis muscle, peritoneum, and intraperitoneal structures were identified

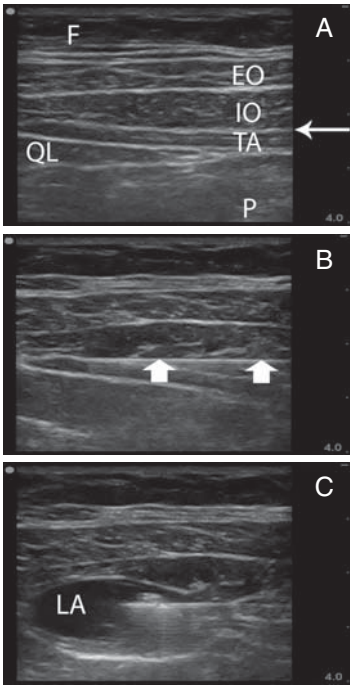

Fig 1 Sonographic anatomy of the US-guided TAP block. Images show the lateral abdominal wall using a probe held in the mid-axillary line in the axial plane. The right of the image is anterior. (A) Narrow arrow, TAP; EO, external oblique muscle; IO, internal oblique muscle; TA, transversus abdominis muscle; QL, quadratus lumborum muscle; F, s.c. fat; P, intraperitoneal structures. (B) Broad arrows, needle with the tip positioned in the TAP. (C) Local anaesthetic forming a lens-shaped space in the TAP; LA, local anaesthetic.

(Fig. 1). To assist with identifying these structures, the probe could be moved anteriorly to the rectus sheath and the fascial planes followed back out laterally. The final position of the probe was to be no further anterior than the anterior axillary line. If satisfactory views were not obtained, the TAP block was not to be performed.

A 150 mm long, 20 G short-bevel needle (Stimuplex, B. Braun Melsungen AG, Germany) was introduced anteriorly and inserted in plane under real-time US guidance to lie between the internal oblique and the transversus abdominis muscles with the tip in the mid-axillary line. The hydrodissection technique[7] was not used to separate fascial layers, but a 1 ml test injection of study solution was permitted to confirm needle location. A total of 20 ml of study solution were injected on each side after aspiration to avoid intravascular placement. Successful injection produced an echolucent lens-shaped space between the two muscles.

All authors performed blocks in this trial. Before the trial, each author underwent a period of self-audit to ensure the TAP block safety and efficacy. Their technique was assessed by the principal investigator (P.J.C.) to ensure uniformity.

All patients received rectal acetaminophen 1 g and diclofenac 100 mg at the completion of surgery. Participants were observed in the recovery room for 30 min after the

procedure. Regular oral acetaminophen 1 g four times a day and ibuprofen 400 mg three times a day were continued after operation. Morphine PCA set at 1 mg bolus, 5 min lockout without an hourly maximum, was continued for 24 h after the procedure. I.V. ondansetron 4 mg and metoclopramide 10 mg were available if required.

The primary outcome measure was total morphine requirements in the 24 h after surgery. Twenty-four hours after surgery, data were downloaded from the PCA pump. Time to first morphine demand and cumulative morphine doses at 6, 12, 18, and 24 h were recorded. Participants completed a questionnaire at this time. They were asked to rate the average pain they experienced over the 24 h postoperative period on a 100 mm visual analogue scale (VAS) between 'no pain' (0) and 'very severe pain' (100 mm). Patients at our institution mobilize within 24 h of surgery; therefore, this score assesses pain at rest and with mobilization. Satisfaction with pain relief was also reported on a 100 mm VAS between 'very unsatisfied' (0) and 'completely satisfied' (100 mm). Participants were asked to rate the severity of nausea, vomiting, itch, and drowsiness on a four-point scale (none, mild, moderate, and severe). Any local complications of the TAP block were recorded. The number of doses of antiemetics administered by nurses was recorded as a measure of antiemetic requirements.

The sample size for this study was based on a 50% reduction in the PCA morphine requirement in 24 h from previous audit data (mean 36.8 mg, SD 20.5 mg). This calculation assumed the use of Student's *t*-test, type I error of 0.05, and a power of 80%. A minimum sample size of 42 participants was required and we aimed to recruit 50 subjects.

Patient characteristics were assessed for homogeneity with Student's *t*-test and Fisher's exact test as appropriate. Continuous data were tested with the Shapiro–Wilk test for normality before applying Student's *t*-test (two-tailed, unequal variances) or the Mann–Whitney *U*-test. Categorical data were tested with Fisher's exact test. $P \leq 0.05$ in the primary outcome measure was considered statistically significant. Statistical significance of secondary outcome measures was not adjusted for multiple comparisons. Analysis was done using SPSS version 15 for Windows (Chicago, IL, USA).

Results

One participant in each group was excluded from the final analysis because their i.v. access failed before 24 h. The PCA was stopped and they received oral opioids. One additional participant in the active group was also excluded from the analysis due to a reaction after the injection of the study solution. The clinical features of pruritus, rash, oedema, hypotension, and hypoxia suggested anaphylaxis. The blinding for this participant

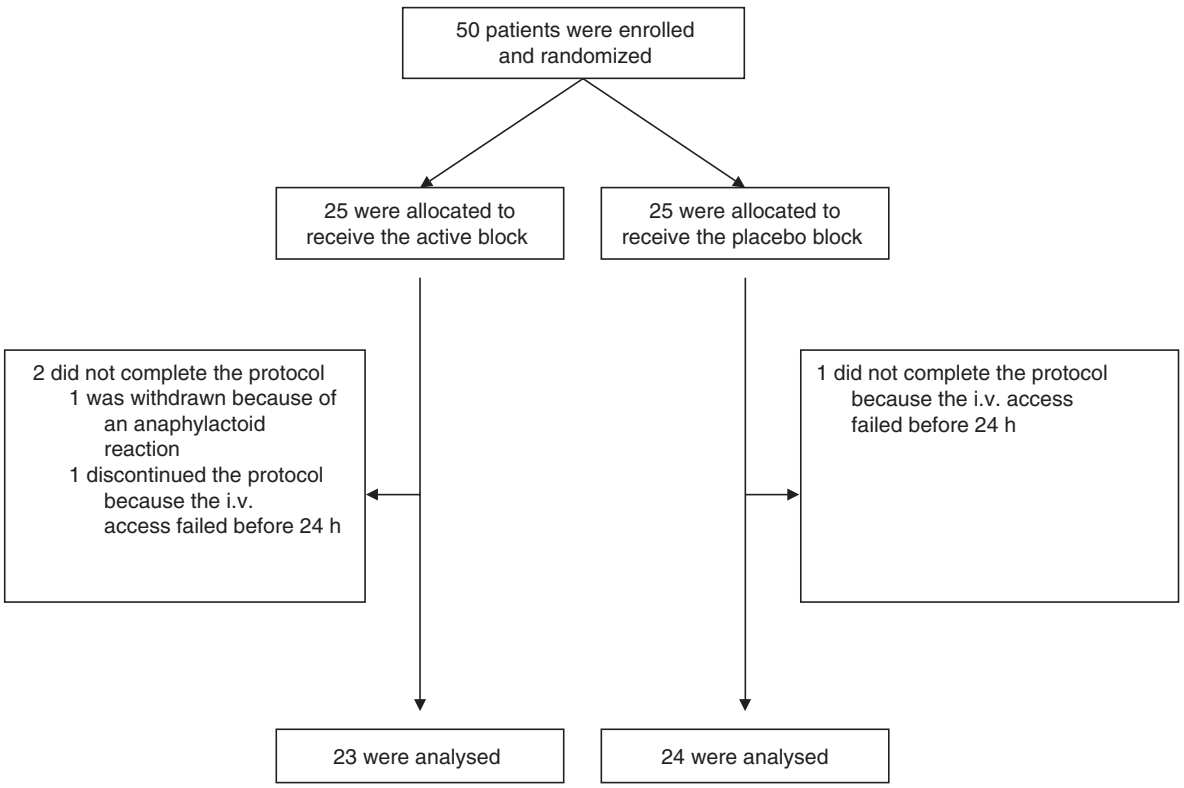

Fig 2 Flow diagram of randomization and follow-up of enrolled participants.

was immediately broken to allow for optimal medical management. The patient was treated with oxygen, fluids, vasopressors, antihistamines, and steroids and improved over 2 h. The mast cell tryptase was not raised and the patient was referred for allergist evaluation. The data for the remaining 23 in the active and 24 in the placebo groups were complete (Fig. 2).

All participants had elective Caesarean deliveries except one in the placebo group who was booked for elective Caesarean delivery but presented to the obstetric unit in early labour. The baseline characteristics of the two groups, shown in Table 1, were not significantly different. US views were satisfactory in all participants.

The morphine use is shown in Table 2. Morphine doses were not normally distributed and non-parametric tests were performed. Cumulative morphine use at 24 h was significantly lower in the active group. The time to first morphine demand was shorter in the placebo group. The median time to first demand was 2 h [inter-quartile range (IQR) 2 h] for the placebo group compared with 3 h (IQR 1 h) in the active group (P=0.01).

Patient satisfaction with pain relief was significantly higher in the active group. Median (IQR) satisfaction scores were 96 (17) and 77 (21) mm in the active and placebo groups, respectively (P=0.008). There was no significant difference in the VAS pain score. The median (IQR) pain score was 26.5 (20) mm in the placebo group and 23.0 (21) mm in the active group (P=0.17).

Fewer patients in the active group received antiemetics (P=0.03). In the placebo group, six participants received either one or two doses of antiemetic during the 24 h period. Only one participant required antiemetics in the active group (three doses). Table 3 shows patient-reported side-effects such as nausea, vomiting, itch, and drowsiness. There was a trend towards less nausea in the active group. There was no difference in patients reported vomiting. Patients in both groups commonly reported pruritus and drowsiness.

There were no serious local complications attributed to the US-guided TAP block in either group. One patient in each group had an s.c. bruise <1 cm in diameter at the injection site.

Table 1 Baseline characteristics of the study participants. PONV, postoperative nausea and vomiting. *No statistically significant differences between the groups for all baseline characteristics

	Placebo (n=24)	Active* (n=23)
Age (yr) [mean (range)]	30.5 (21–43)	32.3 (20–41)
Height (cm) [mean (SD)]	164 (7)	165 (7)
Weight (kg) [mean (SD)]	76.6 (12.4)	74.8 (11.6)
Previous Caesareans, n (%)		
0	5 (20.8)	10 (43.5)
1	13 (54.2)	8 (34.8)
2	5 (20.8)	5 (21.7)
>2	1 (4.2)	0 (0.0)
Previous non-obstetric abdominal surgery, n (%)	2 (8.3)	2 (8.7)
History of PONV, n (%)	5 (20.8)	1 (4.3)

Table 2 Patient-controlled morphine use after surgery. IQR, inter-quartile range. *Mann–Whitney U-test

	Placebo (mg), median (IQR)	Active (mg), median (IQR)	P-value*
Cumulative morphine dose at			
6 h	12.0 (17.0)	6.0 (6.0)	0.039
12 h	16.5 (22.0)	10.0 (8.0)	0.049
18 h	25.5 (28.0)	16.0 (12.0)	0.034
24 h	31.5 (28.0)	18.0 (21.0)	0.046
Morphine dose during time interval			
6–12 h	5.0 (6.0)	4.0 (3.0)	0.226
12–18 h	7.0 (11.0)	4.0 (4.0)	0.143
18–24 h	3.5 (7.0)	4.0 (10.0)	0.966

Discussion

It is well recognized that local anaesthetic techniques can improve the quality of postoperative recovery by reducing pain and analgesic requirements.[8] This randomized, double-blind, placebo-controlled trial demonstrates that the US-guided TAP block has a morphine-sparing effect after Caesarean delivery. The potential for improved recovery with this opioid-sparing technique is demonstrated by greater satisfaction with pain relief and reduced antiemetic use in the active group. The trial was not large enough to demonstrate the likely reduction in postoperative nausea and vomiting.

US guidance should improve the efficacy of the TAP block by allowing the clinician to accurately and consistently deposit local anaesthetic between the internal oblique and the transversus abdominis muscles. Although a statistical comparison cannot be performed, the

Table 3 Participant reported side-effects assessed 24 h after surgery. *Fisher's exact test P=0.08; †Fisher's exact test P=0.35; ‡Fisher's exact test P=1.0

Severity	Nausea, n (%)*		Vomiting, n (%)†		Itch, n (%)‡		Drowsiness, n (%)‡	
	Placebo	Active	Placebo	Active	Placebo	Active	Placebo	Active
None	10 (41.7)	15 (65.2)	17 (70.8)	21 (91.3)	6 (25.0)	6 (26.1)	5 (20.8)	4 (17.4)
Mild	8 (33.3)	7 (30.4)	3 (12.5)	1 (4.3)	13 (54.2)	12 (52.2)	11 (45.8)	11 (47.8)
Moderate	5 (20.8)	0 (0.0)	2 (8.3)	1 (4.3)	3 (12.5)	3 (13.0)	6 (25.0)	5 (21.7)
Severe	1 (4.2)	1 (4.3)	2 (8.3)	0 (0.0)	2 (8.3)	2 (8.7)	2 (8.3)	3 (13.0)

morphine-sparing effect found in our trial appears smaller than that achieved by McDonnell and colleagues'[2] landmark-guided technique. The median morphine dose used in 24 h by the active group in our trial was 43% lower than placebo, compared with almost 80% in McDonnell's trial.[2] This raises the question of whether the US technique deposits local anaesthetic in a less effective location than the landmark technique. Anatomical research, published after the completion of trial recruitment, has shown that T10 to L1 nerves run deep to a thin fascia between the internal oblique and the transversus abdominis muscles.[3] Refining the US technique to position the needle below this fascia using hydrodissection[7] might result in more effective analgesia.

In addition to the use of hydrodissection, the US-guided TAP block technique might be improved by a change of injection site. An audit of US-guided TAP blocks showed the absence of sensory block in the L1 distribution in 50% of patients.[9] This suggests that local anaesthetic does not always spread to the iliohypogastric and ilioinguinal nerves which occasionally enter the TAP in front of the anterior axillary line.[3] The Pfannenstiel incision is partly innervated by the L1 branches and specific blockade of these nerves also results in morphine sparing after Caesarean delivery.[10 11] A TAP injection placed further anteriorly might block the L1 dermatome more reliably and further reduce pain after Caesarean delivery. More research is needed to evaluate how needle position and alteration of local anaesthetic concentration and volume affect the distribution and duration of sensory block.

US guidance for regional anaesthesia has not been conclusively demonstrated to improve safety;[12] however, visceral and vascular injury resulting from TAP blocks might be reduced. There were no serious local complications related to the US-guided TAP block, but one patient had an anaphylactoid reaction immediately after injection of ropivacaine. This is an uncommon but potential risk of any regional anaesthetic procedure.

Effective postoperative analgesia for Caesarean delivery can be provided by neuraxial opioids such as diamorphine, morphine, or meperidine. However, intrathecal opioids can be associated with pruritus, nausea, vomiting, and sedation. If additional opioids are administered, rostral spread of intrathecal morphine can rarely result in delayed respiratory depression. In our clinical experience, adding a TAP block to intrathecal morphine provides little additional analgesic benefit. Further trials are necessary to compare US-guided TAP blocks with intrathecal morphine for tolerability and quality of analgesia.

In summary, this trial demonstrates the analgesic efficacy of the US-guided TAP block after Caesarean delivery. The block has opioid-sparing effects, reduces antiemetic use, and improves satisfaction with pain relief. We believe that the block should be considered in all women undergoing Caesarean delivery who have not received long-acting neuraxial opioids. Further research is essential to establish the optimal use of this relatively new technique.

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