The Analgesic Efficacy of Transversus Abdominis Plane Block After Cesarean Delivery: A Randomized Controlled Trial

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BACKGROUND: The transversus abdominis plane (TAP) block is an effective method of providing postoperative analgesia in patients undergoing midline abdominal wall incisions. We evaluated its analgesic efficacy over the first 48 postoperative hours after cesarean delivery performed through a Pfannensteil incision, in a randomized controlled, double-blind, clinical trial.

METHODS: Fifty women undergoing elective cesarean delivery were randomized to undergo TAP block with ropivacaine (n = 25) versus placebo (n = 25), in addition to standard postoperative analgesia comprising patient-controlled IV morphine analgesia and regular diclofenac and acetaminophen. All patients received a standard spinal anesthetic, and at the end of surgery, a bilateral TAP block was performed using 1.5 mg/kg ropivacaine (to a maximal dose of 150 mg) or saline on each side. Each patient was assessed postoperatively by a blinded investigator: in the postanesthesia care unit and at 2, 4, 6, 12, 24, 36, and 48 h postoperatively.

RESULTS: The TAP block with ropivacaine compared with placebo reduced postoperative visual analog scale pain scores. Mean (± sd) total morphine requirements in the first 48 postoperative hours were also reduced (66 ± 26 vs 18 ± 14 mg, P < 0.001), as was the 12-h interval morphine consumption up to 36 h postoperatively. The incidence of sedation was reduced in patients undergoing TAP blockade. There were no complications attributable to the TAP block.

CONCLUSIONS: The TAP block, as a component of a multimodal analgesic regimen, provided superior analgesia when compared with placebo block up to 48 postoperative hours after elective cesarean delivery.

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been reported to provide effective analgesia in a series of patients undergoing radical prostatectomy. We hypothesized that the TAP block, as part of a multimodal analgesic regimen, would result in decreased opioid consumption and improved analgesia in the first 48 h after cesarean delivery compared with a placebo block. The purpose of this study was to test this hypothesis and observe side effects in patients undergoing elective cesarean delivery via a Pfannenstiel abdominal wall incision.

METHODS

After obtaining approval by the Hospital Ethics Committee, and written informed consent from the patient, we studied 50 ASA physical status I–III patients scheduled for cesarean delivery via a Pfannenstiel incision, in a randomized, double-blind, controlled clinical trial. Patients were excluded if there was a history of relevant drug allergy, or they were receiving medical therapies considered to result in tolerance to opioids.

Patients were randomly allocated to undergo TAP block (n = 25) with 1.5 mg/kg ropivacaine 0.75% (to a maximum dose of 150 mg) per side or TAP block with saline 0.9% (control, n = 25). The allocation sequence was generated by a random number table, and group allocation was concealed in sealed, opaque envelopes that were not opened until patient consent had been obtained. The patients, their anesthesiologists, and staff providing postoperative care were blinded to group assignment. All patients received a standard spinal anesthetic consisting of 12 mg of hyperbaric bupivacaine 0.5% with fentanyl 25 μg. Patients also received rectal diclofenac 1 mg/kg to a maximum of 100 mg and rectal acetaminophen 1 g at the end of surgery. Prophylactic antiemetics were not administered.

The TAP block was performed at the end of surgery by one investigator (J.G.M) using the following technique. A 22-gauge 50-mm blunted regional anesthesia needle (Plexufix®, BBraun, Melsungen AG, Germany) was attached with flexible tubing to a syringe filled with the study solution. A loss-of-resistance technique was used to locate the TAP. This is possible because the fascial extensions of the abdominal wall muscles within the floor of the triangle of Petit create an easily appreciated increased resistance to needle advancement. With the patient in a supine position and the investigator standing on the contralateral side, the iliac crest was palpated from anterior to posterior until the latissimus dorsi muscle insertion was appreciated (Fig. 1). The triangle of Petit was palpated between the anterior border of latissimus dorsi, the posterior border of the external oblique, and the iliac crest. The skin over the triangle of Petit was pierced with the needle held at right angles to the coronal plane. The needle was stabilized and advanced at right angles to the skin in a coronal plane until resistance was encountered. This first resistance indicated that the needle tip was traversing the fascial extension of the external oblique muscle. Further gentle advancement of the needle resulted in a loss of resistance, or “pop” sensation, as the needle entered the plane between the external and internal oblique fascial layers. Further gentle advancement resulted in the appreciation of a second increased resistance as the needle traversed the fascial extension of internal oblique. A second pop indicated entry into the transversus abdominis fascial plane. After careful aspiration to exclude vascular puncture, a test dose of 1 mL was injected. The presence of substantial resistance to this injection indicated that the needle was not between fascial planes, indicating the need to reposition the needle. After a negative test dose, 1.5 mg/kg of

Figure 1. Line drawing of a transverse section through the abdominal wall at the level of the lumbar triangle of Petit (TOP). The floor of the triangle is composed, from superficial to deep, of the fascial extensions of external oblique, internal oblique, and transversus abdominis, respectively, and the peritoneum. The needle is inserted through the triangle, using the loss-of-resistance technique. The needle is shown in the transversus abdominis plane, and the fascial layers have separated as a result of the injection of local anesthetic.
ropivacaine (to a maximum dose of 150 mg each side) was injected through the needle in 37.5 mg increments, whereas observing closely for signs of toxicity. The TAP block was then performed on the opposite side using an identical technique.

After completion of the surgical procedure and block, patients were transferred to the postanesthesia care unit (PACU). A standard postoperative analgesic regimen, consisting of oral acetaminophen 1 g every 6 h and rectal diclofenac 100 mg every 18 h, combined with patient-controlled IV morphine analgesia (PCA) (bolus dose 1 mg, lockout interval 6 min, 4 h maximum dose 40 mg), was commenced on admission to the PACU in both groups. The presence and severity of pain, nausea, and sedation were assessed systematically by an investigator blinded to group allocation. These assessments were performed in the PACU and at 2, 4, 6, 12, 24, 36, and 48 h after TAP blockade. All patients were asked to give scores for their pain at rest and on movement (knee flexion) and for the degree of nausea at each time point. Pain severity was measured using both a visual analog scale (VAS, 10 cm unmarked line in which 0 cm = no pain and 10 cm = worst pain imaginable) and a categorical pain scoring system (none = 0; mild = 1; moderate = 2; severe = 3). Nausea was measured using a categorical scoring system (none = 0; mild = 1; moderate = 2; severe = 3). Nausea was defined as a nausea score >0 at any postoperative time point. Sedation scores were assigned by the investigator using a sedation scale (awake and alert = 0; quietly awake = 1; asleep but easily roused = 2; deep sleep = 3). The presence of sedation was defined as a sedation score >0 at any postoperative time point. Rescue antiemetics were offered to any patient who complained of nausea or vomiting. The study ended 48 h after TAP blockade.

The primary outcome measure in this study was 48 h morphine consumption. Secondary outcome measures included time to first request for morphine, VAS scores, and side effects associated with morphine consumption. For the purposes of sample size calculation, we assumed that a clinically important reduction in 48 h morphine consumption would be a 25% absolute reduction. Based on initial pilot studies, we projected a mean 48 h morphine requirement of 80 mg with a standard deviation of 20 mg in the control group. We calculated that 20 patients would be required per group for an experimental design incorporating two equal sized groups, with \( \alpha = 0.05 \) and \( \beta = 0.2 \). To minimize any effect of data loss, we elected to recruit 25 patients per group into the study.

Statistical analyses were performed using a standard statistical program (Sigmastat 3.5, Systat Software, San Jose, CA). Demographic data were analyzed using Student’s t-test or Fisher’s exact test. The data were tested for normality using the Kolmogorov-Smirnov normality test. Repeated measurements (pain scores, nausea scores) were analyzed by repeated measures analysis of variance if normally distributed, with further paired comparisons at each time interval performed using the t-test. For nonnormally distributed data, between group comparisons at each time point were made using Wilcoxon’s ranked sum test. Categorical data were analyzed using the \( \chi^2 \) analysis or Fisher’s exact test. The time to first request for morphine was analyzed using the log rank test. Normally distributed data are presented as mean \( \pm \) sd, nonnormally distributed data are presented as median (interquartile range), and categorical data are presented as raw data and frequencies. The \( \alpha \) level for all analyses was set as \( P < 0.05 \), and the Bonferroni correction for multiple comparisons was used if appropriate.

### RESULTS

Fifty-two patients were entered into the study. Two patients, one from each group were excluded after enrollment due to postoperative analgesic protocol violations. Of the remaining 50 patients, 25 were randomized to undergo TAP blockade with ropivacaine, and 25 were randomized to undergo TAP blockade with normal saline.

Groups were comparable in terms of age, weight and height, and previous abdominal surgery (Table 1). In all patients, the triangle of Petit was located easily on palpation, the transversus abdominis neuro-fascial plane was localized after one to two attempts, and the block performed without complication.

Patients undergoing TAP block with ropivacaine had reduced 48 h morphine requirements (Fig. 2), and a longer time to first PCA morphine request (Fig. 3). The median (interquartile range) time to first request for morphine was 90 (55, 190) min in the control group, compared with 220 (150, 380) min in patients who received a TAP block. The TAP block with ropivacaine reduced cumulative postoperative morphine consumption compared with placebo block at all time points (Fig. 2). Interval morphine consumption was also significantly lower at 12, 24, and 36 h in the patients who underwent TAP blockade (Table 2). Postoperative VAS pain scores at rest and on movement were reduced after TAP block at some, but not at all, time points assessed (Fig. 4). Categorical pain scores were lower in patients who received the TAP block with ropivacaine.

### Table 1. Baseline Patient Characteristics

<table>
<thead>
<tr>
<th>Group</th>
<th>Control (n = 25)</th>
<th>TAP block (n = 25)</th>
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<tbody>
<tr>
<td>Age (yr)</td>
<td>34 ± 5</td>
<td>35 ± 4</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>78 ± 17</td>
<td>71 ± 10</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.65 ± 0.06</td>
<td>1.64 ± 0.06</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>28 ± 6</td>
<td>26 ± 3</td>
</tr>
<tr>
<td>Previous abdominal surgery [%]</td>
<td>15 (60)</td>
<td>16 (64)</td>
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</table>

Continuous data are presented as mean ± sd. Categorical variables as presented as number and proportion. There were no significant differences between groups. TAP = transversus abdominis plane.
block at all postoperative time points (data not shown).

Five patients developed postoperative nausea in the control group, compared with none in the patients that received TAP blockade. However, there was no significant difference in the incidence of nausea or distribution of nausea scores between groups at any time point. The TAP block significantly reduced the incidence of sedation, from 36% in the control group to zero in the block group. Postoperative sedation scores were reduced in patients who received the TAP block at 6 h postoperatively, but not at the other time points (data not shown).

**DISCUSSION**

This randomized, double-blind, controlled trial demonstrated that supplementing a standard multimodal analgesic regimen with a TAP block resulted in reduced 48 h morphine requirements and pain scores, as well as delayed request for supplemental opioid analgesia, compared with the standard regimen alone.
Cesarean delivery is one of the most commonly performed surgical procedures worldwide, with more than one million patients undergoing this procedure annually in the United States alone.6 The analgesic regimen should provide safe, effective analgesia, with minimal side effects for the mother and her child.

A multimodal analgesic regimen is most likely to achieve these goals. However, the optimal components of this regimen continue to evolve. Although single-shot neuraxial analgesic techniques using long-acting opioids, or patient-controlled epidural opioid administration, produce effective analgesia, they are associated with a frequent incidence of side effects, particularly nausea, vomiting, and pruritus, which reduce overall patient satisfaction.1 In addition, there is a risk of delayed maternal respiratory depression due to rostral spread of hydrophilic opioids such as morphine.7 Furthermore, it is not always possible to provide neuraxial opioid analgesia due to logistic issues and/or the presence of medical contraindications.8,9

Although IV PCA morphine facilitates a greater degree of patient control, and thereby results in high patient satisfaction levels, the analgesia produced is often incomplete, and opioid-mediated side effects remain common.1 There are also concerns in regard to the potential for systemically administered lipophilic opioids such as meperidine to transfer to breast milk and produce transient adverse neurobehavioral effects in the neonate.10 Given these issues, there is considerable potential for a regional technique such as TAP blockade to comprise an effective component of a multimodal regimen for postcesarean delivery analgesia.

Our study demonstrates that the TAP block reduced overall postoperative morphine requirements by more than 70% in the first 48 postoperative hours. The finding that the TAP block reduced morphine requirement for each 12 hourly interval up to 36 h is of importance, in that it demonstrates that a single-shot TAP technique can produce effective analgesia for up
to 36 h. The reasons for the prolonged duration of analgesic effect after TAP blockade may relate to the fact that the TAP is relatively poorly vascularized, and therefore drug clearance may be slowed. The disposition of drug injected into the TAP is currently being studied. The incidence of sedation was reduced in the TAP block group, a finding consistent with a morphine-sparing effect of the TAP block. The TAP block was easy to perform in this patient population, and the technique did not differ from that used in our previous study of patients undergoing surgery via a midline incision. Therefore, the TAP block seems to be effective for patients undergoing surgery involving either midline or lower abdominal incision.

The dose of ropivacaine (3 mg/kg) used in this study is significantly higher than the dose of levobupivacaine used in our previous study, even when differences in drug potency are considered. Our rationale for using a higher dose of local anesthetic stems from our aim to provide prolonged analgesia with a single-shot TAP block. Although relatively high, this dose is within manufacturer guidelines for infiltration anesthesia, such as a field block, or brachial plexus block. However, the dose is higher than that recommended by the manufacturer for infiltration or minor nerve block analgesia for the purpose of postoperative analgesia. Of importance, this dose is within the recommended safe dose range for ropivacaine. Nevertheless, the potential for systemic toxicity with this dose of local anesthetic must be borne in mind, particularly in the setting of recent pregnancy (and increased general vascularity) and inadvertent intravascular injection. The risk of drug transfer to the nursing infant, although likely to be relatively low, is uncertain. Future studies by our group will include plasma concentrations as part of the outcome data.

There are a number of limitations to this study. First, the study limited assessment of postoperative analgesia to the first 48 postoperative hours. However, our data indicate that the severity of pain in the control group has diminished substantially by this time, and most patients no longer require systemic opioid therapy. Second, there are difficulties in adequately blinding these types of studies, given that the TAP block produces loss of sensation of the abdominal wall. Although patients and the investigator conducting the postoperative assessments were technically blinded to group allocation, true blinding may not have been possible. Third, all blocks were performed by the same investigator (J.G.M). Although this was done to decrease variability in the performance of the block, this approach may limit the extent to which our findings can be generalized. Fourth, the study was not large enough to assess safety. There is a risk of inadvertent peritoneal puncture with this block. Although the incidence is not known, if the block is performed as described, the risk of peritoneal puncture is likely to be low. We have not encountered complications relating to peritoneal puncture in the several hundred TAP blocks we performed. The use of ultrasound to confirm needle position is a promising approach that should further reduce the risk of this complication. A further limitation is that we did not assess the success rate of the block or the extent of abdominal wall sensory blockade. This was done to preserve blindling of the assessor. Future studies to determine the success rate of the block, particularly when performed by less experienced users, are required. Finally, we did not perform a dose-response study to determine if a lower dose of ropivacaine would lead to the same results.

We conclude that the TAP block holds considerable promise as part of a multimodal analgesic regimen for postcesarean delivery analgesia. The TAP block was easy to perform, and provided reliable and effective analgesia in this study, and no complications due to the TAP block were detected.

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REFERENCES