Ultrasound-guided transversus abdominis plane block: description of a new technique and comparison with conventional systemic analgesia during laparoscopic cholecystectomy†

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Background. The transversus abdominis plane (TAP) block is usually performed by landmark-based methods. This prospective, randomized, and double-blinded study was designed to describe a method of ultrasound-guided TAP block and to evaluate the intra- and postoperative analgesic efficacy in patients undergoing laparoscopic cholecystectomy under general anaesthesia with or without TAP block.

Methods. Forty-two patients undergoing laparoscopic cholecystectomy were randomized to receive standard general anaesthetic either with (Group A, n=21) or without TAP block (Group B, n=21). Ultrasound-guided bilateral TAP block was performed with a high frequency linear ultrasound probe and an in-plane needle guidance technique with 15 ml bupivacaine 5 mg ml\(^{-1}\) on each side. Intraoperative use of sufentanil and postoperative demand of morphine using a patient-controlled analgesia device were recorded.

Results. Ultrasonographic visualization of the relevant anatomy, detection of the shaft and tip of the needle, and the spread of local anaesthetic were possible in all cases where a TAP block was performed. Patients in Group A received significantly more intraoperative sufentanil and postoperative morphine compared with those in Group B [mean (SD) 8.6 (3.5) vs 23.0 (4.8) mg, \(P<0.01\), and 10.5 (7.7) vs 22.8 (4.3) mg, \(P<0.05\)].

Conclusions. Ultrasonographic guidance enables exact placement of the local anaesthetic for TAP blocks. In patients undergoing laparoscopic cholecystectomy under standard general anaesthetic, ultrasound-guided TAP block substantially reduced the perioperative opioid consumption.

Br J Anaesth 2009

Keywords: anaesthetic techniques, regional; equipment, ultrasound machines; surgery, laparoscopy

Accepted for publication: February 26, 2009

Although laparoscopic cholecystectomy is considered to be a minimally invasive surgical procedure with lower perioperative pain scores compared with open procedures, it is associated with significant levels of postoperative pain.1 2 Usually, standard general anaesthetic is given to patients undergoing laparoscopic cholecystectomy.

However, the use of neuraxial anaesthesia3–5 or of intra-peritoneal local anaesthesia6 has been shown to increase the efficacy of perioperative pain therapy and reduce the consumption of opioid drugs. Peripheral regional anaesthetic techniques could be considered as an attractive alternative to central blocks or high-dose intraperitoneal anaesthesia. The transversus abdominis plane (TAP) block involves the sensory nerve supply of the anterior–lateral abdominal wall, where the T7–12 intercostal nerves, the ilioinguinal and iliohypogastric nerves, and the lateral cutaneous branches of the dorsal rami of L1–3 are blocked with an injection of local anaesthetic between the

†The study was performed at the Department of Anaesthesia and Intensive Care Medicine, King Saud University, College of Medicine, Riyadh, Saudi Arabia.

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The internal oblique abdominal muscle (IOAM) and the transverse abdominal muscle (TAM). TAP blocks are performed for indications such as Caesarean delivery, bowel surgery, or retropubic prostatectomy. Despite the encouraging initial results, the TAP block is not well described in the literature in terms of block technique, success rates, or local anaesthetic plasma levels. So far, the block is performed by so-called ‘pop’ or ‘double-pop’ methods in the anatomical area of the ‘Petit’ triangle, which is located between the iliac crest, the latissimus dorsi, and external oblique abdominal muscles (EOAM). Consequently, inadvertent needle positions with subsequent severe complications are described.

Direct ultrasonographic visualization of the anatomy involved and the spread of local anaesthetic could serve as an alternative technique to perform a TAP block. Only anecdotal reports are available about the use of ultrasound for TAP blocks. Therefore, we designed a prospective, randomized, and double-blinded study to describe the feasibility of ultrasound-guided TAP blocks for laparoscopic cholecystectomy as a part of a concept for balanced anaesthesia with the conventional method of standard general anaesthesia.

**Methods**

After approval by the Ethics Committee of the King Saud University in Riyadh (Saudi Arabia) and written informed consent, 42 patients (ASA I or II), undergoing laparoscopic cholecystectomy, were randomly assigned to receive either a combination of standard general anaesthetic with an ultrasound-guided TAP block (Group A) or sole standard general anaesthetic (Group B). The anaesthesiologist who performed general anaesthesia was blinded to the establishment of TAP block.

Exclusion criteria were blood coagulation pathologies, allergies against amino-amide local anaesthetics, or inability to understand the study protocol. The computer-generated randomization protocol was prepared outside the study centre and delivered in opaque envelopes that were sealed and sequentially numbered.

After premedication with oral lorazepam 2 mg 1.5 h before operation, administration of 500 ml lactated Ringer’s solution via a peripheral venous access was started. Standard monitoring (pulse oximetry, ECG, and non-invasive arterial pressure) was performed, and general anaesthesia was induced with sufentanil 0.2 μg kg⁻¹, propofol 4 mg kg⁻¹, and rocuronium 1 mg kg⁻¹. Subsequently, the trachea was intubated and general anaesthesia was continued with 1 MAC sevoflurane in air/O₂ (F₁O₂ 30%). The lungs were mechanically ventilated using a pressure-controlled mode to maintain ECO₂ between 4.7 and 5.3 kPa. At the beginning of the skin closure, anaesthesia was discontinued and tracheal extubation performed once the patient was awake.

After induction of general anaesthesia, bilateral TAP block was performed under ultrasonographic guidance with a SonoSite M-Turbo transportable ultrasound device (SonoSite™, Bothell, WA, USA) and a linear 6–13 MHz ultrasound transducer. Once the EOAM, IOAM, and TAM were visualized at the level of the anterior axillary line between the 12th rib and the iliac crest (Fig. 1), the puncture area and the ultrasound probe were prepared in a sterile manner. Then, the block was performed with a 21 G 90 mm Facette tip needle and an injection line (Polymedic™ by tenema, Z.I. des Amandiers, France) realizing an ‘in-plane’ ultrasound-guided technique as illustrated in Figure 2. Once the tip of the needle was placed in the space between the IOAM and TAM and negative aspiration, 15 ml bupivacaine 5 mg ml⁻¹ was administered under direct ultrasonographic guidance (Fig. 3). The contralateral block was performed equally.

Skin incision was given in both study groups 15 min after the TAP block. The four ports for the laparoscopic procedure were placed below umbilicus, on the right side and on the left side of the abdominal wall. The subsequent surgical procedure was performed routinely following the
standards of the Department of Surgery of the King Saud University, College of Medicine, Riyadh, Saudi Arabia.

Haemodynamics, 5 min after tracheal intubation, were taken as baseline. If heart rate, non-invasive arterial pressure, or both increased by 15% relative to the baseline measurements, sufentanil 0.1 μg kg\(^{-1}\) was administered. The total amount of sufentanil administration was recorded.

After operation, the patients were admitted to the recovery room, where the analgesia was maintained using a patient-controlled analgesia (PCA) device set to give 1.5 mg bolus administration of morphine without a basic rate and 15 min lock-out time. The correct use of the device was exactly explained during the patient’s informed consent. The patients stayed for 2 h in the recovery room and were then transferred to the ward. During the 2 h in the recovery room and subsequent 24 h on the ward, the total amount of morphine administration was recorded.

After 2 and 24 h, the sites of injection of the TAP block were inspected to detect side-effects such as haematomas or infection.

The sample size calculation was based on the assumption that the patients undergoing laparoscopic cholecystectomy without regional anaesthesia need ~25 μg sufentanil intraoperatively and that the TAP block will reduce the opioid use by 30%. Assuming a power of 80%, a level of significance of 5%, and an SD of 8 μg, it was estimated that 16 patients would be required in each group. The sample size was increased to 21 patients in each group resulting in a power of 90%.

Data are presented as mean (SD), number (%), or ratio as appropriate. After testing for normal distribution, groups were compared using a Mann–Whitney U-test. \(P\)-values of <0.05 were considered significant.

Results

Forty-two patients were included in the study (21 in each group). The patient data are presented in Table 1.

Ultrasoundographic visualization of the external, IOAM, and TAM, of the needle, and of the spread of local anaesthetic was possible in all TAP blocks. No case of blood aspiration during performance of TAP blocks was observed.

Overall, Group A patients required a significantly lower amount of opiates compared with Group B. Seventy-six per cent of patients in Group A received only the induction
dose of sufentanil, whereas all patients in Group B required additional intraoperative sufentanil ($P<0.01$). The demand for intraoperative sufentanil and morphine via the PCA device in the recovery room and during a 24 h observation period on the ward is presented in Table 2.

No side-effects related to TAP block were observed 2 and 24 h after the block.

**Discussion**

The TAP block has been described as an effective regional anaesthetic method for various surgical procedures. The recent study shows that ultrasonographic guidance enables exact placement of the local anaesthetic between IOAM and TAM, resulting in superior analgesia when compared with standard general anaesthetic alone.

The TAP block is described as a technique where the local anaesthetic is administered between the IOAM and the TAM via a superficial landmark between the latissimus dorsi, EOAM, and the iliac crest (triangle of Petit). McDonnell and colleagues investigated a ‘pop’ technique in a cadaver study, where methylene blue was administered and confirmed by CT scan. These initial findings were used in clinical applications by the same authors, where the efficacy of TAP blocks during abdominal surgery and Caesarean delivery was investigated. A total of 41 TAP blocks were performed in both studies with superior postoperative analgesia when compared with pure systemic administration of analgesic drugs.

The ‘pop’ technique is also described for other regional anaesthetic methods such as ilioinguinal/iliohypogastric nerve blocks, where severe complications such as colonic puncture, nerve injury, or unpredictable spread of local anaesthetic with subsequent extension of motor block are reported. It is no wonder that similar complications such as inadvertent puncture of the liver are also reported for the TAP block, and a significant number of unreported cases may be assumed.

Consequently, direct visualization of all anatomical structures, the needle, and the spread of local anaesthetic by ultrasonographic guidance may be associated with an increased margin of safety and optimal block qualities. The use of ultrasound for TAP blocks is reported in only a few cases. Hebbard describes an in-plane ultrasound technique in which a linear ultrasound probe is positioned subcostal and perpendicular to the abdominal wall and a needle insertion point near the xyphoid process. In contrast, Walter and colleagues used an ultrasonographic approach superior to the iliac crest and a needle insertion point in the area of the triangle of Petit. The recent study is the first scientific description of the ultrasonographic-guided technique for TAP block by using a comparative study design. We used also an in-plane technique and a puncture area between the 12th rib and the iliac crest, which is cranial of the triangle of Petit. This puncture area was selected due to anatomical reasons, where the muscle layers in the area of Petit are described as inconstant. In addition, we expected a better cranial distribution by choosing a more cranial needle insertion point. Finally, the ultrasonographic appearance of the three muscle layers was optimal in all study patients.

Since 15 ml local anaesthetic was administered on both sides, the vertical spread of local anaesthetic should cover the area between the iliac crest and the 12th rib. It was possible with this technique to visualize all relevant anatomical structures, the shaft and the tip of the needle, and the spread of local anaesthetic between the IOAM and TAM.

Currently, no controlled data regarding success or complication rates for TAP blocks are available. But previous studies about ultrasonographic-guided regional anaesthetic techniques suggest improved block qualities and safety, which is mainly due to direct visualization of the relevant anatomy, the tip of the needle, and the spread of local anaesthetic. In the recent study, we did not compare the ultrasonographic with a ‘blind’ technique because previous descriptions of TAP blockade are weak and the main focus of our study was the description of the ultrasonographic-guided technique and its efficacy. In addition, recent findings indicate a high percentage of administration of local anaesthetic in adjacent anatomical structures during abdominal wall blocks.

The TAP block raises some important questions. Analgesia qualities of TAP blocks in previous and the recent study are excellent, and systemic opioid demand was significantly decreased when compared with standard general anaesthetic. Nevertheless, no study investigates TAP block without general anaesthesia, and therefore no hard data are available regarding block qualities. The TAP block is a regional anaesthetic technique in which large volumes between 30 and 40 ml local anaesthetic are administered bilaterally. Some authors administer volumes

### Table 1 Patient characteristics. No statistical significant differences were calculated between the study groups. Data are presented as mean (range), mean (SD) or ratio

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Group A</th>
<th>Group B</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>51 (34–65)</td>
<td>43 (22–77)</td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>75 (9)</td>
<td>80 (18)</td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>168 (7)</td>
<td>170 (9)</td>
<td></td>
</tr>
<tr>
<td>Sex (female/male)</td>
<td>16/5</td>
<td>19/2</td>
<td></td>
</tr>
<tr>
<td>Duration of surgery (min)</td>
<td>55 (11)</td>
<td>64 (21)</td>
<td></td>
</tr>
</tbody>
</table>

### Table 2 Intra- and postoperative analgesia demand. Data are presented as mean (SD)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group A</th>
<th>Group B</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intraoperative sufentanil (µg)</td>
<td>8.6 (3.5)</td>
<td>23.0 (4.8)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Morphine (mg) via PCA device (recovery room)</td>
<td>0.9 (0.7)</td>
<td>2.3 (1.0)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Morphine (mg) via PCA device (24 h postoperative)</td>
<td>10.5 (7.7)</td>
<td>22.8 (4.3)</td>
<td>&lt;0.05</td>
</tr>
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</table>
to an extent that a so-called ‘flank bulge sign’ is visible. Pharmacokinetic data during these techniques have never been measured, but recent data indicate that administration of local anaesthetic between fascia layers is associated with fast absorption kinetics and high plasma levels of local anaesthetics. Thus, an important prerequisite for a routine use of TAP block is the knowledge of these data and volume reduction studies where the ‘optimal’ volume for this regional anaesthetic technique should be evaluated. Finally, the optimal puncture site between the iliac crest and the 12th rib is unclear and should be also evaluated in further investigations.

In conclusion, the ultrasound-guided TAP block enables exact placement of the local anaesthetic between the internal and TAM and a significant decrease of systemic analgesics and volume reduction studies where the ‘optimal’ volume for post-inguinal herniorrhaphy analgesia in a pediatric patient. Acta Anaesthesiol Taiwan 2007; 45: 237–40

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