The transversus abdominis plane (TAP) block is a newly described peripheral block involving the nerves of the anterior abdominal wall. The block has been developed for post-operative pain control after gynaecologic and abdominal surgery. The initial technique described the lumbar triangle of Petit as the landmark used to access the TAP in order to facilitate the deposition of local anaesthetic solution in the neurovascular plane. Other techniques include ultrasound-guided access to the neurovascular plane via the mid-axillary line between the iliac crest and the costal margin, and a subcostal access termed the ‘oblique subcostal’ access. A systematic search of the literature identified a total of seven randomized clinical trials investigating the effect of TAP block on post-operative pain, including a total of 364 patients, of whom 180 received TAP blockade. The surgical procedures included large bowel resection with a midline abdominal incision, caesarean delivery via the Pfannenstiel incision, abdominal hysterectomy via a transverse lower abdominal wall incision, open appendectomy and laparoscopic cholecystectomy. Overall, the results are encouraging and most studies have demonstrated clinically significant reductions of post-operative opioid requirements and pain, as well as some effects on opioid-related side effects (sedation and post-operative nausea and vomiting). Further studies are warranted to support the findings of the primary published trials and to establish general recommendations for the use of a TAP block.

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Techniques for TAP block

The TAP block was first described in 2001 in a letter by Dr Rafi,3 and was further developed and tested by McDonnell et al.4–8 In this block, the lumbar triangle of Petit is used as a landmark for injecting local anaesthetic into the neurovascular plane of the abdominal wall, located between the internal oblique and the transversus abdominis muscles. Nerves supplying the anterior abdominal wall are derived from T6 to L1 and pass through this plane before supplying the anterior abdominal wall.5,9 In addition, anatomical dissections have demonstrated that in this plane, the T6–L1 communicate closely and branch widely with neighbouring segmental nerves.9
The triangle of Petit is located with the iliac crest forming the base, the external oblique muscle as the anterior border and the latissimus dorsi muscle as the posterior border of the triangle. The floor of the triangle is made up of fascial extensions of both the external and the internal oblique muscles (Fig. 1). In the triangle of Petit, a blunt regional anaesthesia needle is inserted perpendicular to the skin just cephalad to the iliac crest and behind the mid-axillary line, and the transversus abdominis fascial plane is localized with a two-‘pop’ sensation (or loss of resistance) modus. The first ‘pop’ indicates penetration of the fascia of the external oblique muscle and the second ‘pop’ indicates penetration of the internal oblique muscle and thereby entering the transversus abdominis fascial plane.4 In this neurovascular plane, a local anaesthetic solution can be injected, thus blocking the sensory nerves before innervating the different muscles of the anterior abdominal wall. In volunteers, injection of 20 ml of lidocaine 5 mg/ml produced a sensory block extending from T7 to L1.8 The TAP block may be performed unilaterally but sufficient analgesia after a midline abdominal surgery requires a bilaterally performed TAP blockade.

This ‘blind’ TAP block technique is described as easy to perform and with few complications.3-6,10 However, the triangle of Petit may be difficult to palpate in obese patients3,7 and one case of accidental liver trauma has been described in a patient scheduled for a total abdominal hysterectomy. This patient had an enlarged liver and was of a small stature, and the importance of palpating the edge of the liver before performing the TAP block was pointed out.11

Ultrasound-guided access to the neurovascular plane was initially presented in a letter by Hebbard.12 The ultrasound probe is positioned on the abdominal wall in the mid-axillary line between the iliac crest and the costal margin, and carefully moved postero-laterally for optimal identification of the transversus abdominis fascial plane (Fig. 2). A needle is inserted anterior and inline with the probe and followed visually until correct positioning of the local anaesthetic. Recently, a subcostal access termed ‘oblique subcostal’ has also been described by the same author,13 in which the probe is positioned directly parallel to the costal margin and the needle is introduced near the xiphoid process. It is suggested that this access may be used for optimizing analgesia of the supraumbilical abdominal area.

A variant ultrasound-guided access to the TAP block has also been described for children using a hockey stick probe initially placed just lateral to the umbilicus. When sliding laterally, the muscle layers of the abdominal wall can be identified and local anaesthesia can be deposited close to the origin of the thoracolumbar roots.14
Clinical studies with a TAP block on post-operative pain

Literature search and quality assessment

Randomized, blinded, controlled trials of TAP block for acute post-operative pain relief were systematically sought using the PubMed (http://www.ncbi.nlm.nih.gov/pubmed/) database without language restriction. Free text combinations of the following search terms: ‘transversus abdominis plane block’, ‘post-operative pain’ and ‘post-operative analgesia’ were used. The last search was performed on December 2009. Reference lists of retrieved manuscripts were searched for additional papers.

Study quality (randomization/allocation concealment; details of the blinding process; and description of withdrawal and dropouts) was evaluated using the three-item (1–5) Oxford Quality Scale. Study validity was evaluated using the five-item (1–16) Oxford Pain Validity Scale. Each identified study was read and scored by two of the authors (P. L. P. and O. M.). In case of disagreement between the authors, a consensus was reached by involving a third author (J. B. D.).

Clinical studies

A total of seven randomized, double-blinded clinical trials with a TAP block on post-operative pain were identified. These studies included a total of 364 patients, of whom 180 received TAP blockade (Table 1). Quality scores (median 5, range 2–5) and validity scores (median 14, range 2–15) of the studies were generally high (Table 1). Three of the seven studies were from the same group of investigators.

The surgical procedures included large bowel resection with a midline abdominal incision, a cesarean delivery via the Pfannenstiel incision, abdominal hysterectomy via a transverse lower abdominal wall incision, open appendectomy and laparoscopic cholecystectomy with all four ports of the procedure described as inserted below the umbilicus (Table 1).

In four of the studies, patients received a general anaesthesia and in three studies spinal anaesthesia was performed. In four of the seven studies, a multimodal post-operative analgesic regimen was used including paracetamol 1 g every 6 h and NSAID, either diclofenac 100 mg every 16–18 h or ibuprofen 400 mg every 8 h, in combination with PCA-morphine. In the appendectomy study, patients received a multimodal post-operative analgesic regimen with paracetamol 1 g every 6 h, diclofenac 50 mg as required and PCA-morphine. In one of the cesarean delivery studies, a multimodal analgesic regimen including paracetamol 1 g every 6 h, diclofenac 50 mg every 8 h and intrathecal opioids (fentanyl 10 μg and morphine 100 μg) was used in combination with i.v. morphine 2 mg on request. In the last study, only PCA-morphine was administered (Table 1). No prophylactic antiemetic drug was used in any of the studies.

In three studies, the TAP block was performed bilaterally after induction of anaesthesia, using the blind technique via the triangle of Petit as described under methods. In six studies, the TAP block was performed bilaterally, whereas in the appendectomy study, injection was unilateral. In four of the studies, saline 0.9% was injected as a placebo in the control group, whereas in the remaining studies, no placebo infiltration was performed.

In all but one study, 24-h post-operative PCA-morphine consumption was significantly reduced with the TAP block, ranging from 33% to 74%, compared with the control groups (Fig. 3). A meta-analysis showed a significant reduction in 24 h morphine consumption [WMD: −22 mg, 95% confidence interval (CI): −31 to −13 mg], favouring the TAP block treatment. A subgroup analysis revealed a difference between the outcome for the landmark-based technique (WMD: −38 mg, CI: −61 to −16 mg) and the ultrasound-guided technique (WMD: −11 mg, CI: −19 to −2 mg) (Fig. 4). Three studies investigated for an extended 48 h analgesic effect of the TAP block. Two of the studies reported on a reduced 48 h analgesic requirement, favouring the TAP block treatment. Although the morphine-sparing effect was mainly evident for the first 12 h, a significant opioid-sparing effect was demonstrated in most of the 12-h time intervals in the studies.

Pain scores, both at rest and during mobilization, were significantly reduced with the TAP block in the early post-operative period (0–6 h) in four studies (bowel resection, abdominal hysterectomy, caesarean section and appendectomy). After appendectomy, bowel surgery and abdominal hysterectomy, pain scores were also reduced after 24 h. Furthermore, in the abdominal hysterectomy study, reduced pain scores, both at rest and during mobilization, were reported for up to 48 h post-operatively. In two studies (caesarean section and appendectomy), pain scores...
Table 1

Randomized-controlled studies of a TAP block in post-operative pain.

<table>
<thead>
<tr>
<th>References</th>
<th>Surgical procedure</th>
<th>n active/control</th>
<th>TAP block procedure</th>
<th>Intra-operative anaesthetic</th>
<th>Post-operative analgesics</th>
<th>Effect on analgesic requirements</th>
<th>Effect on pain</th>
<th>Effect on sedation</th>
<th>Effect on PONV</th>
<th>Oxford Quality Score (0–5)</th>
<th>Oxford Validity Score (1–16)</th>
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<tr>
<td>McDonnell et al.</td>
<td>Large bowel resection</td>
<td>16/16</td>
<td>20 ml levobupivacaine 3.75 mg/ml bilateral. LOR-technique via the triangle of Petit</td>
<td>General anaesthesia with propofol and fentanyl</td>
<td>Paracetamol 1 g/6 h, diclofenac 100 mg/18 h, and PCA-morphine reduced from 80 mg to 22 mg/24 h</td>
<td>VAS reduced at rest and during mobilization at 0–24 h post-op</td>
<td>Sedation scores reduced at 4 and 6 h post-op</td>
<td>Incidence of PONV reduced. PONV scores modestly reduced</td>
<td>5</td>
<td>12</td>
<td></td>
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<td>McDonnell et al.</td>
<td>Caesarean delivery</td>
<td>25/25</td>
<td>1.5 mg/kg ropivacaine 7.5 mg/ml bilateral. LOR-technique via the triangle of Petit</td>
<td>General anaesthesia with propofol and fentanyl</td>
<td>Paracetamol 1 g/6 h, diclofenac 100 mg/18 h and PCA-morphine</td>
<td>VAS reduced at rest (2, 4, 6, 12 and 48 h post-op) and during mobilization (2, 4 and 6 h post-op)</td>
<td>Incidence of sedation reduced. Sedation scores reduced at 6 h post-op</td>
<td>No significant difference</td>
<td>5</td>
<td>14</td>
<td></td>
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<tr>
<td>Carney et al.</td>
<td>Total abdominal hysterectomy</td>
<td>24/26</td>
<td>1.5 mg/kg ropivacaine 7.5 mg/ml bilateral. LOR-technique via the triangle of Petit</td>
<td>General anaesthesia with propofol and fentanyl</td>
<td>Paracetamol 1 g/6 h, diclofenac 100 mg/16 h, and PCA-morphine</td>
<td>VAS reduced at rest (4–36 h post-op) and during mobilization (2–48 h post-op)</td>
<td>Incidence of sedation reduced</td>
<td>No significant difference</td>
<td>5</td>
<td>14</td>
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<tr>
<td>El-Dawlatly et al.</td>
<td>Laparoscopic cholecystectomy</td>
<td>21/21</td>
<td>15 ml bupivacaine 5 mg/ml bilateral. UL-guided technique</td>
<td>General anaesthesia with sevoflurane and sufentanil</td>
<td>Paracetamol 1 g/6 h, diclofenac 100 mg/16 h, and PCA-morphine</td>
<td>PCA-morphine reduced from 23 to 11 mg/24 h</td>
<td>No data</td>
<td>No data</td>
<td>2</td>
<td>2</td>
<td></td>
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<tr>
<td>Niraj et al.</td>
<td>Open appendectomy</td>
<td>24/23</td>
<td>20 ml bupivacaine 5 mg/ml unilateral. UL-guided technique</td>
<td>General anaesthesia with isoflurane</td>
<td>Paracetamol 1 g/6 h, diclofenac 100 mg (pn) and PCA-morphine reduced from 50 to 28 mg/24 h</td>
<td>VAS reduced at 30 min and at 24 h post-op at rest and on coughing</td>
<td>No data</td>
<td>Reduced at 30 min post-op</td>
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<td>13</td>
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<tr>
<td>Belavy et al.</td>
<td>Caesarean delivery</td>
<td>23/24</td>
<td>20 ml ropivacaine 5 mg/ml bilateral. UL-guided technique</td>
<td>Spinal anaesthesia with bupivacaine and fentanyl</td>
<td>Paracetamol 1 g/6 h, ibuprofen 400 mg × 3, and PCA-morphine reduced from 36 to 24 mg/24 h</td>
<td>No significant difference</td>
<td>No significant difference</td>
<td>Use of anti-emetic reduced. Nausea and vomiting: No significant differences No data</td>
<td>5</td>
<td>14</td>
<td></td>
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<tr>
<td>Costello et al.</td>
<td>Caesarean delivery</td>
<td>47/49</td>
<td>20 ml ropivacaine 0.375% bilateral. UL guided technique</td>
<td>Spinal anaesthesia with bupivacaine, morphine and fentanyl</td>
<td>Paracetamol 1 g/6 h, diclofenac 100 mg/16 h and morphine on request</td>
<td>No significant difference</td>
<td>No significant difference</td>
<td>No data</td>
<td>5</td>
<td>15</td>
<td></td>
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</table>

LOR, loss of resistance; PCA, patient-controlled analgesia; UL, ultrasound; VAS, visual analogue scale; post-op, post-operatively.
were not reduced, and in the remaining study,\textsuperscript{17} no pain scores were recorded.

Five\textsuperscript{4–6,18,19} of the seven studies reported on PONV and four studies on sedation.\textsuperscript{4–6,19} One study\textsuperscript{18} reported that the incidence and severity of PONV were reduced at 30 min post-operatively with the TAP block, and in another study,\textsuperscript{4} the incidence of PONV was reduced, although the reduction in the nausea scores was modest. Sedation was reduced with the TAP block in three of four studies.\textsuperscript{4–6,19}

None of the studies investigated the distribution of the TAP block by sensory testing. One study reported on an allergic reaction in a patient following injection of the local anaesthetic. No other incidences of complications or failures were reported with the block procedure.

**Discussion**

Based on the results from trials included in this review, it appears that the transversus abdominis plane block has the potential to become a new and important tool in post-operative pain management for patients undergoing surgery involving the anterior abdominal wall. The TAP block was reported to be effective in six of seven trials with regard to reduced post-operative opioid consumption. Furthermore, four of six trials also demonstrated reduced pain scores, both at rest and during mobilization, favouring TAP block treatment.

For patients undergoing colonic surgery in which epidural analgesia is currently the gold standard for post-operative pain treatment, the TAP block may offer a new alternative and without the unwanted motor blockade often accompanied by an effective epidural analgesia. Also, patients with coagulation disorders that preclude the use of a central neuraxial block might be amenable to an efficient alternative for post-operative pain treatment with the TAP block.

As only seven studies have been published so far, however, general recommendations for the use of...
TAP block may seem premature. The results from primary published studies, of which three studies are from the same group of authors, have to be confirmed in future studies. The number of patients included in the studies is rather small, thus masking both potential rare complications with the TAP block, but also a possible reduced incidence of side-effects. The present studies indicate that patients may suffer less from PONV and sedation with the TAP block. The evidence so far, however, is weak, and it is prudent that future trials also focus on this potential advantage of the new block.

The optimal procedure-specific volumes and concentrations of injected local anaesthetic in the TAP block have to be established in future trials. Also, further safety data are warranted including serum concentrations of local anaesthetics after administration.

The analgesic duration of a single administration should be assessed, and continuous techniques should be further studied. The differential effects of the block on different surgical procedures should be investigated and compared. It is not clear whether the ultrasound-guided TAP block, as described by Hebbard, is sufficient for surgical procedures located at both the supra- and the infraumbilical level, or whether upper abdominal procedures need an additional TAP block, e.g. the ‘oblique subcostal’ block, to be efficient.

In the present studies, both the original blind technique and the ultrasound-guided access were described as easy to perform and with few complications. However, recent reviews conclude that ultrasound guidance reduces the block time and the number of attempts, and decreases the block onset time. Another advantage of using an ultrasound-guided technique is that accidental puncture of the internal gastro-intestinal organs reported with the TAP block may be avoided. Furthermore, the position of the lumbar triangle of Petit was investigated in a cadaver study, demonstrating that the triangle was more posteriorly located than described in the literature, and with a relatively small and varying size and shape. In addition, the relevant nerves of the anterior abdominal wall did not always enter the transversus abdominis plane at the point of the lumbar triangle of Petit, thus supporting an ultrasound-guided TAP block access in the mid-axillary line.

Interestingly, our subgroup meta-analysis demonstrated a relatively large difference in morphine sparing between the two TAP-block techniques. It may be speculated whether this difference is related to the anatomical injection sites used for the two techniques, as the Triangle of Petit is located more posterior than the site used in the ultrasound-guided technique. However, it is also possible that the difference in the outcome of the techniques simply reflects a procedure-specific difference in post-operative pain and morphine consumption related to the surgical procedures included in the trials.

The results from two of three of the caesarean delivery studies and also from the abdominal hysterectomy study are remarkable as a relatively large reduction in morphine consumption is demonstrated with the TAP block. However, post-operative pain in these patients can be considered a combination of both somatic (the abdominal wall incision) and visceral pain (internal organs) and the TAP block is not known to block visceral afferents. Therefore, other mechanisms of action with the TAP block have to be considered. In a newly published study, serum concentrations of lidocaine were investigated after a 2 × 20 ml TAP block with lidocaine 10 mg/ml, demonstrating serum concentrations within or just above the therapeutic range for the anti-arrhythmic effect of lidocaine. Therefore, the authors suggested that the analgesic effect in part might be caused by a systemic rather than a local analgesic effect of the local anaesthetic, thus warranting further studies to examine this question.

One study did not find any significant advantage from the use of TAP blockade for patients undergoing a caesarean section. The basic multimodal analgesic regimen in this study included use of intrathecal morphine, a treatment well known for its analgesic efficacy, but with significant side effects. Thus, pain scores and morphine consumption in the control group of this study were low, thereby making it difficult to demonstrate an analgesic improvement from the TAP blockade.

In most of the trials published so far, both pain scores and opioid consumption were reduced. This was achieved with a TAP block added to a basic analgesic regimen consisting of paracetamol and NSAIDs, indicating that the block may be an important part of a multimodal analgesic regimen. Likewise, four cases of laparoscopic appendectomy were reported in a recent letter. In these cases, all patients received a TAP block in combination with paracetamol and NSAID, and none of the patients required supplemental opioid for the first 12 h post-operatively. Two of the four patients did not consume any opioids at all. It is therefore possible that the TAP block may confer special advantages in procedures with small to moderate surgical trauma.
and pain, as in e.g. day case surgery, in which the TAP block has the potential to minimize pain and opioid usage, thereby promoting fast recovery and discharge.

Conclusion

Post-operative pain treatment with a TAP block is a promising new technique, demonstrating both a substantial reduction in morphine consumption as well as improved pain scores in surgery involving the anterior abdominal wall. Before the TAP block is implemented in routine clinical practice, however, further studies are warranted in order to support the findings of the primary published trials and to establish general recommendations for the use of a TAP block, especially as part of a multimodal post-operative analgesic regimen.

References
