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REVIEW ARTICLE

Pediatric regional anesthesia: abdominal wall blocks

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Summary

Abdominal wall blocks are an effective regional anesthetic technique to provide sufficient analgesia in abdominal surgery. This article reviews the use of abdominal wall blocks in pediatric regional anesthesia.

Introduction

In pediatric anesthesia, good and long lasting analgesia is essential to achieve happy children and satisfied parents. To guarantee this, many pediatric anesthetists include a variety of regional anesthetic techniques in their daily clinical practice. In children scheduled for minor abdominal surgery, like inguinal or umbilicus hernia repair, abdominal wall blocks are an effective technique to provide adequate analgesia (1,2). Furthermore, ilioinguinal nerve blocks have been described to be effective in decreasing catecholamine plasma levels. However, caudal blocks resulted in even lower plasma levels than ilioinguinal/iliohypogastric nerve blocks in children undergoing inguinal surgery (3). One has to keep in mind that abdominal wall blocks are not adequate to eliminate visceral pain produced from peritoneal traction or manipulation of the spermatic cord. Therefore, a caudal or an epidural block is often the preferred method of pain relief in infants and children scheduled for inguinal or abdominal surgery. As caudal or epidural blocks may be contraindicated in some circumstances, and side effects like motor palsy of the lower extremity or urinary retention are less frequent in abdominal wall blocks compared with caudal blocks, there is still a wide spectrum of patients who may benefit from an abdominal wall block. Especially in day-case surgery, where a delayed ambulation attributed to side effects of regional anesthesia should be avoided, abdominal wall blocks are an important alternative to caudal blocks.

Abdominal wall blocks include the ilioinguinal/iliohypogastric nerve block, the rectus sheath block, and the transverse abdominal plane (TAP) block. In this article, we review new scientific findings of abdominal wall blocks in pediatric regional anesthesia.

Ilioinguinal/Iliohypogastric nerve block

Ilioinguinal/iliohypogastric nerve blocks provide ipsilateral analgesia in the inguinal area. This block technique has been used effectively in combination with general anesthesia for inguinal hernia, orchidopexy, and varicocele surgery.

Notwithstanding its attractiveness, ilioinguinal/iliohypogastric nerve blocks are not resoundingly successful. Whereas some authors describe this technique as useful as caudal blocks (2), others demonstrated that 35–70% of all patients treated with ilioinguinal/iliohypogastric nerve blocks required supplemental analgesia (4,5).

Over the past years, different techniques have been described to perform this nerve block. In 1979, Von Bahr recommended to draw a line from the anterior superior iliac spine to the umbilicus. After dividing this line into four equal parts, the injection point is at the intersection of the lateral one-forth and the medial three-forth. With the child in a supine position, local anesthetic is injected in a fan shape subcutaneously and immediately deep to the external oblique aponeurosis (6).

In 1989, Sethna and Berde recommended an entry point 1-cm medial and 1-cm inferior to the anterior superior iliac spine (7). From there, the needle is advanced perpendicular to the skin and the local anesthetic is injected after a 'pop' is felt. Over the last years, there is a debate whether the performing anesthetist should look for one or two pops, but until now, none of these techniques was superior to the other. However, there are reports of accidental bowel puncture during landmark-guided ilioinguinal/iliohypogastric nerve blocks, causing severe complications such as peritonitis or bowel obstructing hematoma (8–10). In fact, Weintraud *et al*. (11) reported that only in 14% of the cases, the local anesthetic is administered in the correct anatomic plane between the internal oblique and transverse abdominal muscles, when a landmark technique is used. In the majority of the remaining cases, the local anesthetic was administered within the transverse or internal oblique abdominal muscle. Although the local anesthetic was in the wrong anatomic plane in 86%, three-quarter of these blocks were graded as clinically successful. This finding suggests that a diffusion of the local anesthetic from the primary placement to the targeted nerves does take place.

Furthermore, a study on an ultrasonographic-guided ilioinguinal/iliohypogastric block technique in children found no correlation between patient weight and the depth of both nerves or between patient weight and the distance of the superior anterior iliac spine to the nerve (12). These findings are in accordance with an anatomic study by Van Schoor *et al*., who evaluated different ilioinguinal/iliohypogastric nerve block techniques in dissected neonatal cadavers (13). Van Schoors illustrated that techniques relying on physical measurements are associated with considerable limits when they are applied to all age groups. However, suboptimal position of the local anesthetic does explain the highly variable success rate of this block, when it is performed as a landmark-based technique.

In the past, ultrasonographic-guided ilioinguinal/iliohypogastric nerve block has been proven to be considerably more effective than the traditional landmark-based technique concerning the quality of intra- and postoperative analgesia (12,14). Using real-time imaging, the exact position of the needle tip between the ilioinguinal and iliohypogastric nerves within the correct fascial plane is possible. In addition, ultrasonographic guidance enables the visualization of the spread of local anesthetic around the targeted nerves. Numerous studies demonstrated that ultrasound guidance in regional anesthesia allows a significant reduction in the volume of local anesthetic compared with conventional guidance techniques (15–18). Our study group demonstrated that in ilioinguinal/iliohypogastric nerve blocks, 0.075 ml/kg local anesthetic is sufficient to achieve a clinically effective block (12). This is especially important in neonates and infants who are at risk of local anesthetic toxicity and increased free plasma concentrations of local anesthetics, because of their low plasma concentration of the binding protein alpha-1-acid glycoprotein.

Rectus sheath block

Rectus sheath blocks provide efficient pain relief for umbilical or other midline surgical incisions. This block technique was introduced in adults by Schleich (19) to provide relaxation of the anterior abdominal wall in 1899. Almost 100 years later, Ferguson *et al*. (20) suggested rectus sheath blocks to provide analgesia for umbilical hernia repair in children in 1996. Today, this regional anesthetic technique has become increasingly popular and is used to provide analgesia in children scheduled for umbilical and epigastric hernia repair, laparoscopic surgery, pyloromyotomy, and other small midline incisions.

Two methods have been described in children, both intend to block the terminal branches of 9th, 10th, and 11th intercostal nerve. Courreges and Poddevin (21) suggest a subcutaneous fan-shaped injection around the umbilicus in combination with a second injection, which is made immediately after the rectus sheath has been pierced. The correct needle position is identified by a fascial click triggered when the needle pierces the anterior rectus sheath.

Ferguson *et al*. recommend an alternative technique, where the local anesthetic is injected deep to the rectus muscle within a potential space between the rectus abdominal muscle and posterior aspect of the rectus sheath. As the tendinous intersections do not extend through the whole rectus abdominis muscle to the posterior sheath, it is likely that an adequate volume of local anesthetic is allowed to spread from the xiphoid to the pubic symphysis from one single injection (20). From the anatomic point of view, this technique seems

to be much more effective to provide an adequate analgesia in the whole midline, but there is a substantial possibility to penetrate the peritoneal cavity. Therefore, an injection of local anesthetic next to the posterior rectus sheath carries the risk of intraperitoneal injection and block failure, as well as potential perforation of the gastrointestinal tract (stomach or colon) or even puncture of a mesenteric vessels.

Based on these potential complications associated with a blind approach, we strongly recommend direct visualization by ultrasound in rectus sheath blocks. Until to date, only two studies describe the use of ultrasonographic guidance in rectus sheath blocks. In a paper presented by our study group, the needle was positioned in an out-of-plane technique on top of the posterior rectus sheath under real-time visualization and as the distribution of local anesthetic within the posterior part of the rectus sheath was monitored (22). In the paper of Jose Maria Belen, the needle was introduced in-line with the ultrasound probe as close as possible to the lateral edge of the rectus muscle and advanced slowly and carefully until the tip of the needle was seen just between the aponeurosis of the IOM and transverse muscles (23).

The fact that none of the children in these studies required any additional analgesia in the perioperative period implicates that the space between the rectus abdominal muscle and posterior aspect of the rectus sheath is the correct place to inject the local anesthetic, and that, 0.1 ml/kg is adequate to provide excellent analgesia for umbilical hernia repair.

Transverse abdominal plane block

Over the past 10 years, the TAP block has become increasingly popular for pain relief in abdominal surgery. Rafi (24) introduced this regional anesthetic technique in 2001 as a landmark-based technique to provide postoperative analgesia of the abdominal wall. Performing a TAP block, one aims to block the segmental nerves T9, T10, T11, T12, and L1 within the plane between the transverse abdominal and the internal oblique abdominal muscle by a single injection. The lumbar triangle of Petit (a space bounded by the iliac crest, latissimus dorsi muscle, and external oblique muscle) is used as a landmark, and a two-'pop' sensation indicates the correct needle position. The first 'pop' occurs after penetration of the fascia of the external oblique muscle, and the second 'pop' occurs after penetration of the internal oblique muscle. In general, the blind TAP block technique is described as easy to perform and with few complications. Nevertheless, similar to all abdominal wall blocks, the abdominal cavity and its vulnerable structures are in close proximity to the aimed fascial layer. First reports of peritonitis and liver trauma after TAP block have been published (25,26). Especially in children, we, therefore, recommend to use real-time visualization of the needle tip as often as possible. Initially, Hebbard *et al.* (27) presented an ultrasound-guided technique in 2005. With the ultrasound probe in the midaxillary line between the iliac crest and the costal margin, the block is performed in an in-plane technique.

To date, the TAP block has not been adequately compared with epidural analgesia, which is still the gold standard for postoperative analgesia management in abdominal surgery. In a systematic review of Cochrane database, the authors summarized that right now, there is only limited evidence to prove that TAP blocks reduce opioid consumption and pain scores after abdominal surgery, when compared with no intervention or placebo (28). In fact, there are some reports showing the lack of efficacy of TAP blocks (29,30). One possible explanation is the spread of local anesthetic. A cadaver study demonstrated that with an ultrasonographic-guided single injection of 20 ml of anilin blue dye in the transversus abdominal plane is not sufficient to reach the T9 segmental nerve. In this study, the segmental nerves T10, T11, T12, and L1 were covered by the injected dye in 50%, 100%, 100%, and 93% of the cases, respectively (31).

Apart from a small case series and a description of the block technique itself, there is only one study on TAP block in children available. In this prospective randomized study, an ultrasound-guided ilioinguinal block was associated with better analgesia in the postoperative period following inguinal surgery compared with analgesia provided by a TAP block (32). So, to date, one can only state that a TAP block is not indicated in children scheduled for hernia repair, where an inadequate blockade of the genital branch of the genitofemoral nerve might explain the difference in the analgesic quality. As a lack of data in the pediatric population for other indications (laparotomy, appendectomy, Nissen fundoplication, pyloromyotomy, major abdominal wall surgery, colostomy placement, and closures), there is the need for further randomised controlled trails.

Pharmacokinetic findings

Finally, the authors of this article want to draw the attention to an important finding described by our group. Today, ultrasonographic guidance is very popular in all abdominal wall blocks. It is proven in many studies that ultrasonographic guidance in regional

anesthesia blocks enhanced the success rate and the possible safety of these techniques (12,17,33–35). However, we found faster resorption and higher plasma concentrations of ropivacaine using an ultrasound-guided injection technique compared with a landmark-based technique for ilioinguinal/iliohypogastric nerve blocks in children (36). A possible explanation of these findings is that compared with an intramuscular injection, which happens in about 85% of a landmark-based ilioinguinal/iliohypogastric nerve blocks (11), an injection between two muscles is associated with an increase in the area available for resorption. As in abdominal wall blocks, there is always the intention to inject the local anesthetic between two muscle layers, a consequence of these findings would be a reduction of the dose of local anesthetic. Further research is necessary to understand the pharmacokinetics of local anesthetics in ultrasound-guided regional anesthesia in children. Whenever an abdominal wall block is performed under ultrasonographic guidance, we recommend to choose the dose of local anesthetic carefully and to consider a dose reduction compared with conventional techniques.

Conclusion

Abdominal wall blocks are an effective regional anesthetic technique to provide sufficient analgesia in abdominal surgery in children. Although for abdominal wall blocks, the superiority of the ultrasonographic guidance technique over the landmark technique has been proven in very limited number of studies (11,14), the authors personally think that ultrasound guidance is by far the much better and more effective choice.

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