Peripheral nerve blocks in children

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Introduction

The performance of peripheral nerve blocks in children is similar to adults. Interestingly most of the techniques described below are often underused, and therefore only a few publications are available. We perform the entire spectrum of blocks in our daily clinical practice, and it is important to state that most of ultrasound guided blocks reflect our personal experience and not all techniques are described in the literature in a randomized, prospective and double blinded manner.

Upper extremity Blocks

All nerves of the brachial plexus in children are superficial. High frequent linear ultrasound transducers are therefore appropriate for these indications.

Interscalene brachial plexus block

This type of block is indicated for surgical procedures in the shoulder and upper arm area. Winnie *et al.* originally placed the puncture at the level of the laryngeal prominence on the lateral border of the sternocleidomastoid muscle with the needle in a perpendicular direction. This needle direction used to involve severe complications such as puncture of the epidural space or inadvertent administration of local anaesthetic into the vertebral artery (risk of seizures). The technique was later modified by Meier *et al.*, who used a more cranial puncture site with a more tangential orientation of the needle [1]. The success rates given in the literature vary between 50% and 94%.

The brachial plexus can be readily visualized by ultrasound imaging at the level of the posterior interscalene space. The probing is started laterally to the larynx by visualizing the

thyroid gland, the carotid artery, and the internal jugular vein. As the probe is moved sideways to the lateral border of the sternocleidomastoid muscle with a slight caudal movement of the tip of the probe, the nerve structures become visible in a transverse view as multiple round or oval hypoechoic areas between the anterior and median scalene muscles.

Following skin puncture slightly cranial to the probe, a 22-gauge 4 cm needle with a facette tip is placed in the interscalene space to inject the local anaesthetic under direct ultrasound visualization. A dose of 5–10 ml is normally sufficient to induce complete brachial plexus blockade. The entire brachial plexus can be blocked from this position by slightly repositioning the needle to include the T1 root, which forms part of the ulnar nerve. Also, a catheter can be inserted into the interscalene space if continuous brachial plexus anaesthesia is desired.

Supraclavicular brachial plexus block

The Vienna study group developed an ultrasound-guided technique for the supraclavicular approach and compared it with the axillary approach, demonstrating that a high success rate could be obtained even with ultrasound equipment that was state of the art in 1994 [2].

The entire brachial plexus near the subclavian artery can be visualized by moving the ultrasound probe away from the “interscalene” position described above to a supraclavicular position. As the structures of interest are close to the skin, a high-frequency linear probe (12 MHz or preferably 14 MHz) can be used for optimal resolution. While it is difficult to identify each of the three trunks and the anterior and posterior divisions in a precise manner because of their close proximity, the individual structures of the brachial plexus at this level are adequately mapped for all practical purposes as the probe is slowly moved in a craniocaudal direction. The puncture site is located cranial and posterior to the ultrasound probe using the in-plane technique. Local anaesthetic should be administered to the point of encircling the trunks (usually 3–5 ml). This approach is optimal for catheter placement.

Infraclavicular brachial plexus block

The vertical infraclavicular brachial plexus (VIP) block has been one of the most popular approaches to the brachial plexus since it was described by Kilka *et al.* in 1995 [3]. Reported success rates vary between 88% and 95%. It has been said that anatomical landmarks can be readily identified with this approach, but serious complications have been described as well. The puncture site is located halfway between the jugulum and the ventral part of the acromion.

In an ultrasound investigation into the reliability of the “VIP point”, Greher *et al.* came up with a formula suggesting a somewhat different position [4]. Their findings indicated that the predicted VIP point and the infraclavicular puncture site defined by ultrasound imaging coincided in less than 20% of patients. According to Greher *et al.*, the VIP point is only correct when the distance between the jugulum and acromion is 22 cm. For each centimetre less or more, the puncture site should be moved 2 mm towards the lateral or medially aspect, respectively.

The findings of Greher *et al.* suggest that all infraclavicular brachial plexus blocks should be performed under ultrasound visualization. The distance of the brachial plexus from the pleura can be increased by selecting a more lateral approach to avoid inadvertent puncture of the cervical pleura. In addition, these results have been implemented in paediatric infraclavicular blocks, where a more lateral approach should be used [5]. The so-called “Lateral infraclavicular plexus block” shows significant advantages in comparison with axillary blocks in terms of onset, duration and extent of block, even when a nerve stimulator will be used. Using a high frequent linear ultrasound probe the fascicles as well as the pleura are visible and an even more effective block in comparison with nerve stimulator guidance could be performed [6].

Axillary brachial plexus block

This approach is still the most popular technique for blockade of the brachial plexus. Although complications are generally rare, one author reported three cases of serious permanent neurologic injuries. Also, the reported success rates of 70–80% are hardly acceptable. These problems may be caused by failure to block the radial nerve after puncture above the axillary artery. Whatever the case may be, the axillary approach involves many open questions despite its great popularity.

Retzl *et al.* described the use of high-resolution ultrasonography to identify nerves at the axillary level [7]. They observed that the position of the main nerves of the brachial plexus was not constant relative to the axillary artery but changed significantly on applying even mild pressure (e.g. during palpation of the axillary artery). This observation may also help to explain the high failure rate of axillary brachial plexus blocks.

Ultrasound guidance for axillary brachial plexus anaesthesia should be performed with a high-frequency probe (≥ 12 MHz, in younger children > 13 MHz). The median nerve can be readily visualized, as it is located right next to the axillary artery all the way down to the cubital level. The ulnar nerve located medial to the artery and remains closer to the skin surface than the median nerve all the way down to the proximal forearm. The radial nerve, which is located below the artery, may be somewhat of a problem. While it is sometimes difficult to visualize because of the acoustic shadow cast by the artery, the anaesthesiologist can still move the probe slightly in a dorsal direction to visualize the radial nerve at the level of the humerus where it branches off from below the artery to enter the radial nerve sulcus.

A 22-gauge 4 cm should be inserted 1 cm below the artery, blocking each of the three major nerves with tiny volumes of local anaesthetic. The musculocutaneous nerve originates in the lateral fascicle. Being located between the coracobrachial and short head of the biceps muscles, it is usually separated from the other nerves at the level of the axilla, such that it cannot be reached by axillary injection of the local anaesthetic. In most patients, the musculocutaneous nerve can be readily visualized by ultrasound and effectively blocked by injecting another 1-2 ml of the local anaesthetic after moving the needle slightly in a cranial direction. The ultrasound guided axillary approach to the brachial plexus is strictly a multi injection technique.

Descriptions of axillary plexus blocks in children are rare [5,8,9]. The implementation of ultrasonography in the daily clinical practice should improve the efficacy of this regional anaesthetic technique also in children.

Lower Extremity Blocks

Psoas compartment block

The psoas compartment block shows usually a blockade of all nerves of the lumbar plexus, but it shows a high number of complications (e.g. kidney or colon puncture). Additionally common anatomical considerations, that the position of the lumbar plexus is sandwiched between the quadratum lumborum muscle and the psoas muscle does not reflect the anatomical thought. It has been shown that the lumbar plexus is positioned within the psoas muscle.

However it shows some advantages over the 3-in-1 block and neuraxial anaesthesia as well. The advantage compared with the 3-in-1 block is that all nerves of the lumbar plexus are blocked with the psoas compartment block and in combination with a sciatic nerve block all surgical procedures, including hip surgery, can be anesthetised sufficiently.

Kirchmair et al. described the exact anatomical considerations and the use of ultrasonography for psoas compartment blocks [10]. Despite the performance of ultrasound guided psoas compartment blocks in children seems to be easier in comparison with adults it is still an advanced technique.

For the psoas compartment block we use a 2 to 5 MHz sector probe (in younger children also a higher frequent linear probe could be used), which provides a better penetration depth, which is necessary for this application. The patient should be placed in a lateral decubitus position with thigh flexed trunk, similar to that for spinal anaesthesia, with the operative extremity uppermost. The scanning head has to be placed paravertebral of L4 in a transacted view. For the first orientation the spinal process the articular and the transverse process has to be seen. The erectus spine and quadratus lumborum muscles give further orientation. In many cases the kidney can also bee recognized in this plane. When we have found a position which enables to see all these anatomical findings, the US-machine has to be adapted (penetration depth and focus) to have an optimal imaging. After that the probe has to be shifted down slightly to create an imaging in which the sound beam walks between the transverse processes of L4 and L5. In this position the psoas muscle is visible. Using an in plane technique the needle has to be positioned within the psoas compartment muscle and a response to nerve stimulation can be confirmed. The LA injection to the right place can be monitored additionally.

3-in-1 Block

3-in-1 blocks in children are a widely used regional anaesthetic technique [11,12]. The use of ultrasound should improve block qualities. The anatomical landmarks are clearly visible using a linear 5-12 MHz probe. The femoral vein is medial of the femoral artery and lateral to the vessels the femoral nerve can be detected in its position below the iliopectineal arch.

Immediately under the inguinal ligament the femoral nerve divides in many braches. The major branch, which is the saphenous nerve, is close to the femoral artery. With high frequent linear probes it is also possible to visualize this sensory end-branch of the femoral nerve [13].

The ultrasound guided 3-in-1 block should be performed close to the inguinal ligament using the cross sectional technique. Once the vessels and the nerve have been identified the needle has to be inserted in the short axis technique and placed close to the femoral nerve. The local anaesthetic injection can be monitored with the ultrasound. When the nerve is surrounded by local aesthetic an appropriate blockade of the nerve can be predicted. In clinical practice 3 to 10 mL are sufficient for a successful block.

Similar to adults, it is not clear if the obturator nerve is included in the regional anaesthetic technique. The current recommendation is that the obturator nerve should be blocked separately in cases of requirement of a specific block.

Sciatic nerve blocks

Ultrasonographic guided sciatic nerve blocks in children are a relatively new topic [14,15]. In principle all approaches are possible under direct ultrasonographic control. We perform infragluteal, midfemoral and popliteal approaches in the daily clinical practice.

The sciatic nerve is in some cases difficult to visualize in ultrasonography because of its anisotropy, which describes the optimal visibility of nerve structures dependent on the angle of the ultrasound beam.

Head & Neck Blocks

Head and neck blocks have been used in children and adults for decades. However, there has been greater interest in the use of these blocks in children due to the advantage of decreasing postoperative adverse effects associated with opioids.[16]

Supraorbital & supratrochlear blocks: These blocks are used for patients undergoing surgery to the forehead and scalp.[20] We have used it in conjunction wioth other blocks of the head and neck for craniotomies.[17]

Technique: After careful preparation of the forehead, a 30G needle is inserted at the level of the pupil on the eybrow. A subcutaneous injection of local anesthetic (0.5mL) is injected. This provides analgesia for the scalp anterior to the coronal suture.

Infraorbital blocks: This block is useful for surgeries performed on the upper lip including cleft lip surgery.[18] , endoscopic sinus surgery[19] as well for surgery on the maxilla. The infraorbital foramen is located at the level of the pupil, at the inferior border of the orbital rim.

Technique; an intraoral approach is our preferred approach. After eversion of the lip, a 27-G needle is inserted at the level of the subsulcal line advancing the needle to the infraorbital foramen. After careful aspiration, 0.5 to 1 mL of local anesthetic solution is injected.

Superficial cervical plexus blocks: The superficial cervical plexus supplies the sensory nerves to the pinna, mastoid area, temporal area of the scalp as well as the anterior neck and a ‘cape-

like' distribution along the shoulder. We have used this block for tympanomastoid surgery in out practice.[18]

Technique; A 27-G needle is inserted along the posterior border of the sternocleidomastoid and the level of the cricoid, after aspiration a subcutaneous injection of local anesthetic 1 – 2 mL is injected.

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