REVIEW ARTICLE

Ultrasound Guided Peripheral Nerve Blocks in Pediatric Patients on The Basis of Anatomical Areas; Upper and Lower Extremities: A Narrative Review

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A real time visualization of the peripheral nerves and adjacent anatomical structures, with ultrasound guidance, represents a new developmental technique in regional anesthesia and with more significance for pediatric patients. The main goal of this review was to explain the advantages of the ultrasound to guide the peripheral nerve block in the pediatric population for upper and lower limbs surgeries, and to show if there exists any superiority of the ultrasound technique over other traditional techniques in terms of increasing the success rate or reducing the rate of complications.

keywords: **ultrasound guided; sonography; regional anesthesia; nerve block; pediatric**

Ultrasonography represents noninvasive and real time visualization of internal structures including nerves to be blocked, vessels, needle, catheter, and local anesthetic distribution. However, its application needs some basic skills [1]. Recently published articles in pediatric anesthesia demonstrate significant advantages in ultrasound guiding regional anesthesia of the upper and lower limbs, involve the faster sensory and motor blockade and extended duration of sensory blockade compared with using nerve stimulation alone in children [2]. In addition to reduce the muscle contraction pain that is associated with nerve stimulation with the feasibility and efficiency of ambulatory peripheral nerve catheters in pediatrics [3]. Ultrasound has added many advantages in field of pediatric anesthesia. In this narrative review we searched the current literature available on MEDLINE, EMBASE and Cochrane Evidence Based Medicine Reviews. Furthermore, citation reviews and manual search of new journals related to pediatric anesthesia or surgery were done. The goal was to review studies about regional anesthesia in pediatrics with peripheral nerve block techniques by comparing ultrasound-guided peripheral nerve block of the upper and lower extremities either alone or by combination with at least one other technique of nerve identification such as; anatomical landmark, paresthesia, or using of a nerve stimulator. All the selected reviews were limited to the English language.

Ultrasound and the Anatomical Consideration for Pediatrics

In regarding to the anatomical and physiological features, pediatric population can be considered as a unique group if compared with the adult population, the anatomical structures are different than with adults, smaller and are situated more tightly to each other and to the adjacent blood vessels, and the nerves located more superficial to the skin, add to that the traditional land mark techniques are not reliable in all pediatric patients as a result of the variability in age and size in this group, in other words the pediatric group are not homogenous population, but they range from neonate to an adolescent and follow to that the depth of nerves and plexuses varies with the age ranging [4].

Ultrasound and the Technical Consideration for Pediatrics

In comparison with adults group, the pediatric population has more body water contents, and that affords better identification of anatomical structures like nerves and plexuses under the ultrasound beam than with adults group, furthermore the ossification of bony tissues is less with pediatrics than adults, makes the images of ultrasound beam very distinctive and high quality. The superficial position of the nerves, plexuses and other structures in infants and young children makes them easy to be identified and visualized by the ultrasound probe. An appropriate equipment to the patient size and age should be prepared for that. In particular the needle size should be small enough to be easy for adjustment and to avoid nerve injury, the ultrasound transducer should have appropriate footprint and good resolution suitable for superficial structures in pediatrics [4].

Ultrasounds for Upper Extremities

The upper limbs are mainly innervated by brachial plexus which is formed by the union of the ventral rami of the C5 to C8 and a part of the T1 roots. Anatomically, the important

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variable between infants and adults is that the superior part of the lung and apical pleura enter the neck, above the superior thoracic aperture, thus any perisubclavian approach will be at big risk for pleural invasion [5]. Ultrasound guidance for supraclavicular and infraclavicular approaches, allows good localization of the parietal pleura and vessels, thus improving the safety by visualizing the needle along the procedure. Interscalene and periclavicular approaches in pediatrics are not considered easy and need to be performed by trained operators, on the other hand the axillary and forearm blocks seem easier especially for those who are new to ultrasound-guided regional anesthesia [6]. Indications for brachial plexus blocks includes surgeries of the upper extremity [7-8].

Ultrasound Guided Interscalene Approach

The Interscalene block is not very common in pediatric patients due to its potential adverse effects associated with this area such as pneumothorax, intrathecal injection, and inadvertent injection into vertebral artery. In addition, this technique preferably needs to be performed by an anesthesiologist expert in nerve block. Ultrasound imaging increases the safety of this approach [9-10]. Based on Taenzer et al. [11], there is not any significant difference performing ultrasound guided interscalene block under GA in comparison with awake adults regarding the safety issues. Phrenic nerve blockade, the risk of vascular damage and accidental cervical epidural or intrathecal injection are some of the adverse effects. The ideal position for a child is a supine position with the arms extended alongside the thorax and the head slightly turned to the contralateral side. Due to a short neck compared to an adult, a small roll below the shoulder is advised [4].

Ultrasound Guided Supraclavicular Approach

The using of ultrasound guide for this approach is extremely recommended for pediatric patients to allowing real time visualization of the needle tip and lung parenchyma at this level, thus avoiding the plural puncture and pneumothorax which is a common adverse effect in this approach. Ultrasound technique increased the safety profile of this approach so that with the experienced operators it could be one of the most reliable and effective approach to block the brachial plexus in children [12]. Supraclavicular approaches are indicated for the surgical procedures on the shoulder or on the proximal part of the arm, including the elbow [13-14].

Ultrasound Guided Infraclavicular Approach

The aim of these approaches is blocking the divisions or the cords of the brachial plexus. Marhofer et al. [9] reported that Ultrasound guidance infraclavicular brachial plexus blocks offer faster sensory and motor responses and a longer time of sensory blockade than nerve stimulation in pediatric patients. This block can be applied for arm, forearm and also for hand procedures [12].

Ultrasound Guided Axillary Approach

The axillary block is the most common, easiest and safest approach in pediatric patients, with the goal of blocking the terminal branches of the brachial plexus in the axilla level. Even with the different techniques and procedures that have been described, there is no difference in clinical outcomes in the pediatric population. Inadvertent arterial puncture and intraneural injection are the most undesirable feared complication. It is usually thought intraneural injection is the main cause of permanent nerve damage and mostly undetected in the patient under general anesthesia [12].

Ultrasound Guide for Elbow and Forearm

Ultrasound imaging extends the indication of the elbow and forearm approaches for pediatric regional blocks, however, these approaches are not so common in pediatrics [12]. Approaching the radial, median, or ulnar nerve at the elbow or wrist has long been limited to support the partially failed brachial blocks. It is not difficult to block median and ulnar nerves at any point of their way from the wrist to the axilla due to the superficial location of them, but care should be taken at the level of the wrist because it is often difficult to differentiate between the nerves and the tendons since they have the similar appearance [1]. With a small amount of local anesthetic solution, a complete block can be achieved [12].

Ultrasound guide for lower extremities

The lumbar plexus is composed by the ventral rami of the first three lumbar roots and the greater part of the ventral ramus of the fourth root with variable input from the T12 and L5. The lumbar plexus is located in the psoas compartment in the paravertebral space. From this emerging place, it divides into four nerves that innervate the anterior part of the upper border of the lower extremity. Those are femoral, lateral cutaneous, genitofemoral, and obturator nerve.

Ultrasound Guide for Psoas Compartment Block

It is a direct lumbar plexus block which produces a block of all lumbar and some sacral nerves, thus providing anesthesia of the anterior thigh. The usual indications for this plexus block involve the surgeries on the hip or femoral shaft (femoral and hip osteotomies), which need blockage of the three main nerves innervating the hip joint: femoral, lateral femoral cutaneous, and obturator nerve. Recent studies showed that psoas compartment block can produce excellent postoperative pain relief during the first 48 hours in pediatrics [12]. With the guidance of ultrasonography, studies reported that the depth of the lumbosacral plexus correlated with weight rather than age [15]. For major surgical procedures like major hip or femoral surgeries, continues psoas compartment block provides good management of pain relive in pediatrics [16-18]. most complications for this block including cardiac arrest from the inadvertent intravascular injection, psoas muscle hematomas, epidural anesthesia, and retroperitoneal

injection if the needle site is deeper [16].

Ultrasound Guided Femoral Nerve Block

Ultrasound guidance makes femoral block technique even easier [19]. New studies showed that the use of ultrasonography to perform femoral block in children has many advantages, including prolonged duration of analgesia and decreased the injected local anesthetic volume compared with neurostimulation technique, in other hand, the duration of analgesia was considerably increased [19]. "Keith and Fred [20] reported that a femoral nerve block is now easier, more effective, and better tolerated by emergency department pediatric patients with the use of ultrasound guidance. Ultrasound-guided femoral block in pediatric patients, reduced the utilization of nerve stimulation techniques, achieved faster onset and long duration of action. Intravascular or intraneural injections are the most possible complications [21].

Ultrasound Guided Sciatic Nerve Block

The sacral plexus is formed by the union of the anterior rami of the last two lumbar nerves (L4-L5) and the first three sacral nerves (S1-S3) with the variable share from the fourth sacral nerve (S4). Two nerves originate from the sacral plexus to innervate the lower extremity: the posterior cutaneous nerve of the thigh and the sciatic nerve. Indications for sciatic nerve block are; analgesia and anesthesia for any surgery of lower leg and foot usually accompanied by a femoral, obturator, or saphenous nerve block. This block usually is complemented by saphenous nerve block. Van Geffen et al [22] reported that ultrasound guided proximal Subgluteal and distal sciatic nerve blocks in children was successful and postoperative pain relief was excellent with no complications.

Ultrasound guided subgluteal sciatic approach

It is a common approach for children which can be performed in different positions such as supine, lateral, or prone position, Ultrasound guidance with or without neurostimulation facilitates the success of this block [22], the continuous Subgluteal block is a well-accepted technique that possible to be easy performed associated with good postoperative pain management in the major ankle or foot pediatric procedures [22].

Ultrasound Guided Popliteal Sciatic Approach

A popliteal nerve block is a particularly simple and easier to master as the sciatic nerve is easily identified in this place rather than in the proximal approaches. The simplicity of inducing the analgesia catheter made this approach the first choice in major surgical procedures on foot and ankle in pediatrics. [23]. Ultrasound guidance plays an important role in this level of approach. The sciatic nerve is usually visualized laterally and superficially to the popliteal artery [22]. Ideally, the block should be performed before the branching the sciatic nerve into tibial and common peroneal nerves to gate the best result. Distal sciatic nerve block relieves pain for major foot and ankle surgeries with continuous sciatic nerve block that permits for easy performance, good quality, long duration of analgesia and less dosage of local anesthetic agents [24-27]. A continuous popliteal nerve block is superior to continuous epidural block in children undergoing major foot and ankle surgery, even both techniques have shown excellent analgesia postoperatively but the first one was associated with less urinary retention, lower discontinuation of local anesthetic infusion, and lower incidence of nausea and vomiting [27].

Conclusion

Ultrasound guidance increases the success rate of peripheral nerve blocks applied to pediatric patients for upper and lower extremities depending on the outcomes gained from the studied reviews. The advantages are: block performance time was significantly decreased [28], good visualization of the anatomical structures, needles, catheters, and the spread of local anesthetic agents [28-29], decreased the incidence of failed block, and extended analgesia duration [28], decreased pain scores at one hour in the post-anesthesia care unit [17]. Also with ultrasound guidance, the inadvertent blood vessels punctures were significantly reduced [30]. The use of ultrasonography to guide the peripheral nerve blocks in pediatric population made these procedures more safe and with little complications, either alone or in concomitant with the traditional nerve stimulator [22,31,32], ultrasound guidance facilitated the catheter placement for continuous nerve blocks [22,30], and induced less intraoperative consumption of opioids compared with other techniques [28]. Less volume of local anesthetic was necessary to perform the block [22,28,33]. The application of regional anesthesia has been expanded by the emerging of ultrasonography guidance. A real-time visualization of the needle position and the spread of the local anesthetic drugs around the nerves gave the priority for this technique to become the standard practice for peripheral nerve block, the injected volume of local anesthetic was less with ultrasound guidance for both upper and lower extremities [22,33]. Pediatric regional anesthesia continues to grow to be a new standard for pediatric pain control. Worries to use of regional blocks under general anesthesia have largely been eliminated now since ultrasound guided blocks are routine [34].

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