Peripheral Nerve Blocks In Children

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The goal of placing peripheral nerve blocks (PNBs) is to specifically target analgesia to the location of the surgery so that side effects may be kept to a minimum (Ross et al, 2000). Success of placing peripheral nerve blocks is often a function of knowledge of the anatomy and use of the appropriate equipment (Sethna and Berde, 1992).

To locate a nerve or plexus, one should begin with the nerve stimulator set at 1 to 1.2 mAmps and advance the needle until the desired motor response is achieved. Once the nerve stimulator’s voltage is less than 0.5 mAmps and slight muscle stimulation remains present, local anesthetic is injected. Look for other warning signs of intraneural injection such as intense muscle stimulation with 0.2 mAmps, difficulty with injection or increased heart rate.

Upper Extremity Nerve Blocks

Anatomy

The brachial plexus contains the anterior branches of spinal roots C5 through T1. There is a natural separation between the supraclavicular and infraclavicular plexus at the coracoid process that ultimately affects spread of local anesthetic (Vester-Andersen et al, 1986).

Axillary Block

Axillary block is the most common approach to the brachial plexus in children and is suitable for procedures on the hand such as syndactyly repair and finger reimplantation. Advantages of performing an axillary block include the simplicity of the anatomy, ease of placement and low risk of complications (Tobias, 2001). Disadvantages include the need to abduct the arm and the inability to block the musculocutaneous nerve 40 to 50%.

Technique

Palpate the axillary artery. Insert the needle adjacent and superior to the artery high in the axilla at a 30 to 45 degree angle aimed toward the midpoint of the clavicle. Using a nerve stimulator, and after evidence of muscle stimulation in the hand is observed, local anesthetic is injected. After needle removal, adduct the arm to release the pressure of the head of the humerus from the fossa. The musculocutaneous nerve is blocked by directly inserting the needle into the belly of the coracobrachialis muscle while looking for stimulation of biceps. In addition, if a surgical tourniquet is to be used and the patient is not having a general anesthetic, then the intercostobrachial nerve should be blocked. This is accomplished by placing a subcutaneous ring of local anesthetic high around the inner aspect of the arm.

Complications

There is the rare risk of hematoma and nerve compression. If inadvertent axillary artery puncture occurs, firm pressure should be held for at least 5 minutes to avoid formation of hematoma and subsequent vascular insufficiency (Merril et al, 1981).

Lateral Vertical Infraclavicular Block

A lateral vertical infraclavicular brachial plexus (LVIBP) block can be performed without arm abduction and it provides better analgesia of upper arm than an axillary block (Fleischmann et al, 2003).

Technique
With the child in the supine position, the upper arm should remain next to the trunk and the elbow flexed 90 degrees so that the forearm is on the abdomen. Palpate the coracoid process and insert a 1 inch 24 gauge insulated needle 0.5 cms distal to the coracoid process in a perpendicular or vertical direction while continuously aspirating for blood and/or air. Once appropriate stimulation has been determined and continuous aspiration for blood and/or air has been negative, local anesthetic solution is then injected.

**Complications**

Complications using this approach are rare. There may still be risk of inadvertent pleural or vascular puncture, however these risks should be less than other approaches to the brachial plexus.

**Parascalen Block**

The parascalen approach to the brachial plexus was developed by Dalens to minimize the risks of vertebral artery puncture, dural puncture or pneumothorax, i.e., risks associated with an interscalene block (1995).

**Technique**

With the child supine and a roll under the shoulders, adduct the arm next to the trunk and turn the head to the opposite side. The primary landmarks are Chassaignac’s tubercle (transverse process of C6) and the midpoint of the clavicle. Draw a line between these two structures and insert a needle at the junction of the upper two thirds and lower one third of this line.

**Complications**

Complications using the parascalen approach are rare but may include venous puncture, Horner’s syndrome and hemidiaphragmatic paralysis secondary to phrenic nerve paralysis.

**Dosing of Upper Extremity Blocks**

In general, if using 0.25 to 0.5% bupivacaine or levobupivacaine, or 0.2 to 0.5% ropivacaine, the lower concentrations should be used in children 5 years of age or less at a volume of 0.5 mL/kg. Epinephrine 5 mcg/mL should be added to the solution. Approximately 4 to 12 hours of analgesia should be achieved.

**Lower Extremity Nerve Blocks**

The lumbar plexus consists of the anterior rami of lumbar nerves L1-L4 with a small portion of the twelfth thoracic nerve and ultimately divides into the femoral, the lateral femoral cutaneous, and the obturator nerves. The femoral nerve is a mixed nerve with motor innervation to the quadriceps muscles and sensory innervation to the anterior and medial thigh. A branch of the femoral nerve, the saphenous nerve, provides innervation below the knee to the medial aspect of the lower leg and foot near the saphenous vein. The lateral femoral cutaneous nerve is a sensory nerve with innervation to the lateral thigh, and the obturator nerve is primarily motor to the leg adductors with some sensory to the lower medial thigh and knee.
The sacral plexus is derived from the anterior rami of L4, L5 and S1-3 and gives rise to the sciatic nerve and the posterior cutaneous nerve of the thigh. The sciatic nerve is a mixed nerve that provides motor and sensory innervation to the posterior aspect of the thigh and the majority of the lower leg. As the sciatic nerve travels down the posterior thigh, it branches into the common peroneal and posterior tibial nerves.

**Lateral Femoral Cutaneous Nerve Block**

The lateral femoral cutaneous nerve (LFC) may be blocked to provide analgesia for muscle biopsy (Wedel, 1989; Rosen and Broadman, 1986; Maccani et al, 1995).

**Anatomy**

The LFC arises from second and third lumbar nerves and travels deep to the iliacus fascia towards the anterior superior iliac spine until it emerges under the fascia lata in the upper thigh.

**Technique**

No nerve stimulator is required to block the LFC it is purely a sensory nerve. In the infrainguinal approach, insert a blunt 22 gauge needle perpendicular to the skin aiming in the direction of the nerve inferolaterally 0.5 to 1 cm below the inguinal ligament and medial to the anterior superior iliac spine. A pop will be felt as the needle pierces the fascia lata. Inject local in a fanlike manner (McNicol, 1986).

**Complications**

There are no known serious complications from an isolated LFC except direct nerve trauma.

**Femoral Nerve Block**

A femoral nerve block may be used for any above the knee surgery of the lower extremity that requires analgesia of the majority of the thigh. The block is simple to perform either with or without a nerve stimulator, however a nerve stimulator should not be used in an awake child with a femur fracture due to the pain that may occur with muscle contraction from nerve stimulation.

**Anatomy**

The femoral nerve is derived from lumbar nerves 1 to 3, enters the thigh within the femoral triangle below the inguinal ligament and lateral to the femoral artery.

**Technique**

Insert the needle with a slight cephalad angle at 0.5 to 1cm below the inguinal ligament and 0.5 to 1 cm lateral to the artery. As the needle pierces the fascia lata, a distinct pop is felt. If a nerve stimulator is used, the desired muscle response should be contraction of the mid quadriceps with a “patellar kick”.

**Complications**

Complications include puncture of the femoral artery. In that event, pressure should be held for at least 5 minutes to avoid the formation of a large hematoma.
Fascia Iliaca Compartment Block

The fascia iliaca block provides analgesia of the femoral, lateral femoral cutaneous and obturator nerves and are useful for all above the knee lower extremity surgeries because of their ability to anesthetize this region in its entirety.

Anatomy

The 3 distal nerves of the lumbar plexus, the femoral, lateral femoral cutaneous, and obturator nerves all emerge from the psoas muscle and run along the inner surface of the fascia iliaca. A fascia iliaca compartment block delivers local anesthetic between the fascia iliaca and iliacus muscle where it spreads to bathe the 3 nerves.

Technique

With the child in the supine position, the inguinal ligament is located by drawing a line from pubic tubercle to anterior superior iliac spine. Divide the inguinal ligament into thirds. At the junction of the lateral 1/3 and medial 2/3 of the inguinal ligament, drop a line inferiorly 0.5 to 2 cms and perpendicular to the ligament. This is the point of needle insertion. A blunt needle is used and is inserted perpendicular to the skin. Two pops are felt as the needle first pierces the fascia lata, then the fascia iliaca. If light pressure is held upon the plunger of the syringe, a loss of resistance is felt as the fascia iliaca is pierced.

Complications

Complications during a fascia iliaca block include isolated femoral block.

Sciatic Nerve Block

A sciatic nerve block is indicated for surgical procedures that involve the lower extremity below the knee. When used in combination with blocks of the lumbar plexus, the lower extremity may be blocked in its entirety.

Anatomy

The sciatic nerve is derived from the anterior rami of L4-S3 and is the largest nerve in the body. It emerges through the greater sciatic foramen to run between the greater trochanter of the femur and the ischial tuberosity prior to taking its position in the thigh posterior to the quadriceps femoris. If the sciatic nerve is blocked in its proximal position, this will also anesthetize the posterior femoral cutaneous nerve (a branch of ventral rami of S1-S3). This nerve innervates the posterior thigh above the knee and the hamstring muscles. The sciatic nerve primarily consists of two nerves, the tibial and common peroneal nerves, which travel in a common sheath in the posterior upper portion of the leg. These nerves divide near the popliteal fossa and innervate the leg below the knee.
Several approaches to the sciatic nerve have been described in children. To block the sciatic nerve using the posterior approach, a modification of Labat’s technique was developed by Dalens and others (1990). The child is placed in the lateral position with the side to be blocked uppermost and the upper leg flexed at both the hip and knee. Insert the needle at the midpoint of the line that extends from the tip of the coccyx to the greater trochanter of the femur, perpendicular to the skin with slight angulation towards the lateral ischial tuberosity. Complications of the posterior approach to the sciatic nerve include vascular puncture of gluteal vessels.

The Raj block was developed in 1975 and is similar to the posterior approach (Raj and others, 1975). This block is performed in the supine child with the leg to be blocked lifted and flexed at the hip and knee. Insert the needle at the midpoint between ischial tuberosity and greater trochanter in the sciatic groove. By flexing the hip, the Raj technique brings the sciatic nerve closer to the skin. This improves the likelihood of a successful block, especially in obese children and adolescents.

A popliteal fossa block may be used for procedures of the distal lower extremity (Kempthorne and Brown, 1984). Although 10% of the population may have branching of the sciatic nerve proximal to the popliteal fossa and high in the posterior thigh, both common peroneal and tibial nerves are usually blocked by this approach due to a common epineural sheath that envelops the two nerves (Vloka and others, 1997). Insert the needle 45 degrees to the skin aiming cephalad and just lateral to the midline of the popliteal triangle. The distance from the popliteal fold to needle insertion is estimated based on weight. If the weight is < 10 kg, the distance is 1 cm; if the weight is 10 to 20 kg, the distance is 2 cm (Konrad and Johr, 1998). Each 10 kg of body weight should move the needle cephalad in the triangle approximately 1 cm.
Dosing of Lower Extremity Blocks

The volumes of local anesthesia depend on the nerves to be blocked. For femoral nerve blocks 0.2 to 0.75 ml/kg are administered, while for plexus blocks volumes of greater than 1 mL/kg are frequently needed. When used in combination, local anesthetics are additive. It is important not to exceed maximal allowable dosing.

Continuous Peripheral Nerve Catheters

Indwelling catheters may be placed for peripheral nerve analgesia for those procedures that will either result in significant and prolonged postoperative pain or in whom vascular insufficiency is a risk. Although there is not extensive literature on placing continuous catheters for peripheral nerves or plexus anesthesia in children, there is equipment available that is suitable for these younger patients.

Dosing of an indwelling catheter for plexus anesthesia should adhere to maximal allowable dosing guidelines. Typical doses should start at 0.1 to 0.2 mL/kg/hour of either bupivacaine or levobupivacaine 0.125 to 0.25% or ropivacaine 0.1 to 0.2%. Increases of the infusion rate may be made as needed as long as the maximal infusion rate does not exceed 0.2 mg/kg/hr in infants less than 6 months or 0.4 mg/kg/hr in children older than 6 months of age.

The use of disposable pumps for continuous delivery via a peripheral catheter of local anesthetic solutions has become popular in the adult population for outpatient orthopedic surgery. Dadure and others described the use of the disposable elastomeric pumps in 25 children aged 1-15 years receiving continuous infusion via catheters in the popliteal, femoral or axillary sheaths (2003). A continuous infusion of 0.2% ropivacaine was used at a rate of 0.1 mL/kg/hr. The median pain score for all children was zero up to 48 hours and there were no adverse events.

Ilioinguinal/iliohypogastric Nerve Block

Ilioinguinal/iliohypogastric (ILIH) nerve block provides analgesia to the inguinal area and provides good perioperative pain relief for patients undergoing such procedures as inguinal hernia repair, orchiopexy and hydrocelectomy (Hannahall and others, 1987; Casey and others, 1990; Fisher and others, 1993.

Anatomy

The ilioinguinal and iliohypogastric nerves originate from the lumbar plexus and pierce the transversus abdominis muscle. The iliohypogastric nerve then takes its course between the transversus and internal oblique muscles and the ilioinguinal runs between internal oblique and external oblique.

Technique

Insert a 22 or 25 gauge needle 1 cm superior and 1 cm medial to the anterior superior iliac spine. Contact the inner superficial lip of the ileum, then withdraw while injecting local anesthetic. Once the skin is reached, the needle is redirected toward the inguinal ligament (assuring that the needle does not enter the ligament) and local anesthetic is injected after a “pop” is felt as the needle penetrates the oblique muscles.

Dosing

Ropivacaine or bupivacaine 0.25 mL/kg in 0.2-0.25% may be used.

Complications

Although complications from an ilioinguinal/iliohypogastric nerve block are generally rare and minor, there have been case reports of colonic and small bowel perforation (Johr and Sossai, 1999; Amory et al, 2003). Inadvertent femoral nerve blockade and motor block of the quadriceps may occur if the local anesthetic solution spreads below the inguinal ligament during the block placement. This can yield a block similar to the fascia iliaca block (Roy-Shapiri et al, 1985).