Novel Approaches in Regional Anesthesia & Pain Management

Chapter 2

Regional Analgesia and Anesthesia in Children

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1. Introduction

Regional techniques in pediatrics are increasingly used in the perioperative medicine. Intraoperative and postoperative pain control in infants and children is one of the basic fields of any anesthesiologist, and regional anesthesia plays currently an important role to both chronic and acute pain control. Although commonly performed in the pediatric population through the years, these techniques have also being critized when performed under sedation or general anesthesia since some complications cannot be reported. However, safety studies support regional techniques under general anesthesia as a safe practice.

The use of ultrasound guidance has also improved the efficacy and safety of regional techniques in children. It also allows to minimize local anesthetic dosage and decreases secondary complications by locating anatomical structures and drug administration. Thus, advances in high frequency ultrasonography have increased the scope of regional techniques in pediatrics.

In this chapter we will provide updated description and indications for commonly regional techniques in children along with anatomical characteristics and potential complications.

2. Local Anesthetics in Children

The safety in the use of local anesthetics in the pediatric population is directly related to the understanding of local anesthetic pharmacology. Special physiological characteristics in children, (decreased in drug clearance and low protein binding), make safe dosing guidelines a fundamental item before performing any technique. Secondary side-effects and toxicity are

more likely to occur in children due to an increased in cardiac output, an increased in distribution volume and elimination half-life, lower protein-bind union and plasmatic colinesterase concentration and decreased liver activity. These characteristics make local anesthetic metabolism reduce so maximum toxic dose should always be taken into account to avoid excessive adminiscxtration.

Neurological complications related to local anesthetic toxicity could be successfully treated by administering benzodiazepines and/or propofol. However, cardiac complications are better treated when lipid emulsion is used in dose of 2-5 ml/kg of 20% Intralipid (up to 10 ml/kg). Resuscitation techniques may also be performed when necessary, endotracheal intubation for airway management and mechanical ventilation could be needed.

When catheter has been used for local anesthetic administration, removal, when possible, is encouraged to avoid future complications.

3. Neuraxial Techniques

3.1. Caudal analgesia

Caudal analgesia technique is one of the most commonly used in children for perioperative control of analgesia. It is also frequently performed for postoperative an chronic pain management. Although it is preferred for sacral and lumbar levels, it can also reach lower thoracic and upper abdominal levels. It can be performed guided by ultrasound in plane or by palpating the anatomical landmarks that are very easy to recognize.

3.1.1. Indications

The same as those for lumbar epidural block. Especially surgery of perineum, anus, rectus, urethral surgery, cystoscopy, inguinal and femoral herniorrhaphy, vaginal hysterectomy.

3.1.2. Technique

After positioning the patient in lateral decubitus (usually fully anesthetized), the posterior iliac spines should be located, and a triangle may be marked on the skin over the sacrum. The apex may be located adjacent to the sacral hiatus. The sacral two sacral cornua may be palpated 4 cm more cephally at the upper end of the natal cleft.

A 17-18 gauge Tuohy-type needle is inserted using an angle of 45 º in the midline of the caudal canal and a slight “snap” may be felt when advancing the needle as the sacrococcygeal ligament is penetrated. Once the needle reaches the ventral wall of the sacral canal, it should be withdrawn and reoriented more cranial in a 25 º angle for further insertion. Bupivacaine 0,125-0,25% or ropivacaine 0,1-0.375% with 1:200000 epinephrine at a dose from 0,5-1,5 ml/kg is commonly administered.

3.2. Epidural Analgesia

The epidural technique is a useful tool to control perioperative analgesia by inserting a catheter usually at L4-L5 or L5-S1 levels. It is normally performed by location the midline in the intercristal line that crosses between L5-S1 level in the newborn and that in L5 in older children. With a loss-of-resistance technique with air or saline the epidural space is located and the catheter may be inserted. It is also possible to insert a catheter in the thoracic or even caudal regions. The most commonly used local anesthetics are ropivacaine and bupivacaine following a suggested regimen **(See table**)

DRUG	INITIAL BOLUS	SOLUTION	INFUSION LIMITS
Bupivacaine	< 2.5-3 mg/kg	0.0625-0.1%	< 0.4-0.5 mg/kg h
Ropivacaine	< 2.5-3 mg/kg	0.1-0.2%	< 0.4-0.5 mg/kg h
Morphine	10-30 mcg/kg	5-10 mcg/ml	1-5 mcg/kg h
Fentanyl	1-2 mcg/kg	2-5 mcg/ml	0.5-2 mcg/kg/h

4. Peripheral Nerve Block

As mentioned above, ultrasonography has expanded the use of regional techniques in children by improving correct administration and avoiding complications and improving safety. The location of the different peripheral nerves allows to open a new era of regional anesthesia and increase other possibilities.

5. Upper Extremity Blocks

The brachial plexus offers a wide range of options to be blocked by using the ultrasound. It can be located either in the axillary, infraclavicular, interscalene or supraclavicular areas. The supraclavicular block is the most common technique in children but since the ultrasound offers the possibility to visualize different structures other locations are nowadays being performed.

5.1. Supraclavicular Block

This supraclavicular block provides good analgesia to the upper arm and elbow and, as discussed above, is the most common upper extremity block in children.

5.1.1. Indications

Most upper extremity procedures

5.1.2. Technique

The probe is located superior to the border of clavicle to locate the subclavian artery that is just located next to the brachial plexus. The trunks and divisions of the brachial plexus are

well visualized and needle insertion can be performed in-plane medially in a lateral to medial direction to avoid intravascular puncture.

Complications include intravascular injection, pneumothorax, hematoma and infection.

5.1.3. Dosing

0.2-0.4 mL/kg 0.25% bupivacaine or 0.2% ropivacaine.

5.2. Infraclavicular Block

This block also provides good quality analgesia for the upper arm and elbow. The lateral cords of the brachial plexus can be located by the ultrasound in the medial-inferior area to the coracoid process. The medial cord can sometimes be difficult to visualize. The axillary artery and pectoral minor and major are also good references.

5.2.1. Indications

Most upper extremity procedures, catheter placement.

5.2.2. Technique

It is usually performed following a lateral approach after positioning the probe below the clavicle and the needle is commonly inserted out of plane. The needle is the directed laterally to avoid vascular structures. The same complications as in the supraclavicular block are present for this technique.

5.2.3. Dosing

0.2-0.3 mL/kg 0.25% bupivacaine or 0.2% ropivacaine.

5.3. Interscalene Block

Using the approach the trunks and roots of the brachial plexus can be located between the anterior and middle scalene muscled posterior to the sternocleidomastoid muscle and achieve good analgesia for the shoulder and proximal humerus.

5.3.1. Indications

Shoulder procedures, catheter placement.

5.3.2. Technique

The probe is located in the transverse plane at the level of the cricoid cartilage to iden-

tify the sternocleidomastoid muscle and anterior and middle scalene muscles. It also allows to see the hyperechoic structures of C5-C7 nerve roots and with an in-plane approach the blockade can be safety performed.

The use of ultrasound can decrease the number of complications such as intravascular injection, pneumothorax, intrathecal injection and the secondary effects of hemidiaphragmatic paralysis, recurrent laryngeal nerve block and Horner syndrome are also described.

5.3.2. Dosing

0.2-0.4 mL/kg 0.25% bupivacaine or 0.2% ropivacaine.

5.4. Axillary Block

5.4.1. Indications

This block is a common technique used in children to allow analgesia in the elbow, forearm and hand.

5.4.2. Technique

The median, radial, ulnar and musculocutaneous nerves can be located around the axillary artery, although the musculocutaneous nerve is situated outside of the axillary vascular sheath. An in plane approach is used after locating the probe transversally to the humerus. Complications include intravascular injection, neural damage and hematoma.

5.4.3. Dosing

0.2-0.4 mL/kg 0.25% bupivacaine or 0.2% ropivacaine.

6. Abdominal Wall Blocks

Although traditionally performed by anatomical references, abdominal truncal blocks can be safety and successfully performed with the use of ultrasonography.

6.1. Transversus Abdominal Plane Block

This block is also known as `TAP block´ and can provide analgesia for the anterior abdominal wall. It is a good option for simple abdominal surgical procedures that do not affect internal organ manipulation, as it can be for port skin incision in laparoscopy.

6.1.1. Indication

Abdominal wall procedures, umbilical hernia, laparoscopic procedures.

6.1.2. Technique

Locating the TAP plane is necessary to perform this block. The probe is positioned next to the umbilicus to visualize the three muscle layers of the abdominal wall: the rectus abdominis, the external oblique and the transverses abdominis. The TAP plane is located between the internal oblique and the transverses abdominis muscles where the T8-L1 thoracolumbar nerves lie. The administration of local anesthetic should be placed in this area. Complications are described as bowel puncture, intravascular injection and infection.

6.1.3. Dosing

0.1-0.2 mL/kg 0.25% bupivacaine or 0.2% ropivacaine.

6.2. Rectus Sheath Block

This technique allows to provide analgesia for the anterior abdominal wall and the midline, so It is a good block for postoperative umbilical hernia repair and single incision laparoscopic surgery. By administering local anesthetic in the sheath this technique permits to block the thoracolumbar nerves T-T11

6.2.1. Indication

Umbilical hernia repair, Single incision in the anterior abdominal wall.

6.2.2. Technique

The ultrasound probe should be placed lateral to the umbilicus to obtain a perspective of the rectus abdominis. The posterior rectus sheath lies under the rectus abdominis with a two-layer with the peritoneum. The needle can be advanced in plane or out of plane until the sheath is reached. Complications include the same as for the TAP block

6.2.3. Dosing

0.1-0.2 mL/kg 0.25% bupivacaine or 0.2% ropivacaine.

6.3. Ilioinguinal/Iliohypogastric Block

This technique provides analgesia for the inguinal and anterior scrotum areas so it is a good choice for inguinal hernia repair.

6.3.1. Indication

Hernia repair, groin surgery

6.3.2. Technique

The ultrasound probe should be located medial to the anterior superior iliac spine in line with the umbiliculs. The three abdominal muscle layers that are identified are the external oblique, internal oblique and transverses abdominus. The ilioinguinal and iliohypogastric nerves are located between the internal oblique and transverses abdominis. Complications include pelvic hematoma, bowel puncture, infection, intravascular injection and femoral nerve damage.

6.3.3. Dosing

0.075-0.2 mL/kg 0.25% bupivacaine or 0.2% ropivacaine.

7. Lower Extremity Blocks

7.1. Femoral Nerve Block

The block of the femoral nerve is commonly used for interventions of the knee. This nerve innervates the anterior area of the thigh and the knee and it is conformed by the L2, L3 and L4 nerve roots. Since the vascular structures can be identified by the ultrasound, this block is a safe and successful technique. It can also permit to insert a catheter to provide continuous analgesia in the postoperative period.

7.1.1. Indications

Knee surgery or procedures on the anterior thigh.

7.1.2. Technique

The probe should be placed transversally to the femoral sheath in the inguinal area to identify the vascular structures; the femoral vein is located medial to the artery and the femoral nerve is lateral to the femoral artery. Doppler ultrasound could also be used to identify the vascular structures as in young children and infants the vascular structures can be hard to visualize. The in-plan technique is more common to administer the local anesthetic surrounding the femoral nerve in a single shot, but out-of-plane techniques have also been described.

Complications include infection, intravascular injection, and nerve injury.

7.1.3. Dosing

0.2-0.4 mL/kg 0.25% bupivacaine or 0.2% ropivacaine

7.2. Sciatic Nerve Block

This nerve innervates the posterior area of the thigh and the area of the leg distal to the leg

except the medial portion. This block can also be used in addition to the femoral nerve block to knee procedures. It is originated from nerve roots of L4-S3 and courses distally through the posterior popliteal fossa where it is divided into the tibial and common peroneal nerves where it is usually block.

7.2.1. Indications

Ankle, and foot surgical procedures. Knee surgery as an addition to the femoral nerve block.

7.2.2. Technique

In pediatric patients the anterior approach can be useful since patients are usually anesthetized before injection and can be performed in the supine position. To do this, the probe is placed in the inferior to the inguinal crease and the femur can then visualized and medial and more posterior the sciatic nerve can be identified. In older children this can be difficult since the nerve lies deeper. This nerve block can also be performed in the popliteal fossa after identifying the popliteal artery since the tibial nerve lies next to the artery. Following this nerve cranially, the junction in the common peroneal nerve can be identified. Complications include the same as described for the femoral nerve.

7.2.3. Dosing

0.15-0.3 mL/kg 0.25% bupivacaine or 0.2% ropivacaine.

7.3. Saphenous Nerve Block

This block is a good option to control analgesia for the knee and the medial portion of the leg below the knee so it is a good complimentary blockade to obtain a more complete analgesia of the leg together with a common peroneal nerve block.

7.3.1. Indications

Knee, medial portion of the leg below the knee and the foot

7.3.2. Technique

The probe should be placed in the medial portion of the knee to locate the sapheneous nerve adjacent to the sartorious muscle. The local anesthetic can be administered by an in-plane technique to locate the needle in the sapheneous nerve.

Complications are the same as mentioned in the femoral and sciatic nerve blocks

7.3.3. Dosing

0.1-0.2 mL/kg 0.25% bupivacaine or 0.2% ropivacaine.

7.4. Lumbar Plexus Block

This is a complex nerve roots that innervates the lower abdomen and the upper leg and can be safely performed in children. The plexus originates from the T12 to L5 nerve roots and include the femoral, lateral cutaneous femoral, genitofemoral and obturator nerves.

7.4.1. Indications

Surgical procedures on the hip, knee or foot.

7.4.2. Technique

The probe is located lateral to the midline after identifying the iliac crest and the spinous processes. After locating the psoas major muscle, the lumbar plexus can be seen within.

Complications include retroperitoneal bleeding, infection or haematoma.

7.4.3. Dosing

0.2-0.3mL/kg 0.25% bupivacaine or 0.2% ropivacaine

8. Conclusion

Recent advances in ultrasonography have increased to use of regional techniques in pediatric patients along with an increase in safety and efficacy. These techniques have a wide range of applications for surgical procedures and/or postoperative or chronic pain control. Although it is important to take into account the dosing regimes as well as possible complications caused by the use of these regional blocks, prospective studies have shown a positive effect in the pediatric perioperative medicine.

9. References

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