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Regional anesthesia in children: indications and limitations

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Abstract

The goal of regional anesthesia in infants and children is perioperative and postoperative pain relief. The use of regional anesthesia and analgesia provide improvement in patient outcomes, and may be helpful in special situations, such as premature babies, patients with neuromuscular disorders or non-fasting children presenting for urgent surgery. Application of ilioinguinal and rectus sheath blocks, transverses abdominal plane blocks and wound infiltration with local anesthetics is commonly performed in combination with general anesthesia. Continuous central and perineural infusion of local anesthetics remains the technique of choice for prolonged major surgery or intense postoperative pain. Caudal block still remains the most important and safe technique. Introduction of nerve stimulators and lastly ultrasound guided regional anesthesia techniques reduced the risks and increase the benefits of this kind of anesthesia. The safety profile of regional anesthesia presented in surveys is superior with the very low incidence of serious complications. The aim is to find the safest technique for realizing the anesthesia and analgesia in children where a benefit overcomes the risk.

HISTORY OF PEDIATRIC REGIONAL ANESTHESIA

Regional anesthesia becomes very popular in pediatric population. Central nerve blocks, like spinal and caudal (epidural) blocks are widely used not only in modern European centers, but also in developing countries.

Regional techniques in children started more than 100 years ago, by August Bier in 1899, reported first spinal anesthesia applied in child *(1).* Few years later (1909) Gray published the first large scale series with spinal anesthesia in children undergoing various surgical interventions *(2).*

The second renaissance of regional anesthesia in children was in 1980s, in which period the concerns about risks of regional anesthesia were raised. However, performed scientific studies improve the beneficial effects of these techniques in infants and children *(3–5).*

The third period of regional anesthesia in children is his growing with technology developments. Introduction of nerve stimulators and lastly ultrasound guided regional anesthesia techniques reduced the risks and increase the benefits of this kind of anesthesia.

INDICATIONS FOR REGIONAL ANESTHESIA IN CHILDREN

Indications for regional anesthesia depend on the type of intervention, the age of child and the anesthetist's experience. This kind of anesthesia is widely used in urologic, orthopedic and lower abdominal surgery, and also in cardiac surgery. The other indications for this kind of anesthesia are the all cases in which is general anesthesia contraindicated, like full stomach and risk of aspiration, difficult intubation, allergy to general anesthesia, pseudocholynesterase deficiency or history of malignant hyperthermia. Regional anesthesia can be used in patients with upper airway or pulmonary infections.

The block selection is depended on age. In neonates and infants, two kinds of blocks are mostly used: spinal and caudal epidural. Peripheral nerve blocks are used in older children, mostly, below 6 years old.

When we talk about indications and benefits of regional anesthesia in pediatric population, we must compare it with general anesthesia.

Risk of morbidity and mortality is highest in children under 1 year of age during general anesthesia. However, most operations are avoided during this period; surgery performed on neonates is often emergency surgery. Anesthetic concerns relate mostly to the airway and cardiovascular systems, but some of the metabolic and neuromuscular disorders may have life-threatening reactions with anesthetic agents. The morbidity related to regional anesthesia in children, based on retrospective and prospective studies, is low, 1: 1000 overall *(6–9)*.

Drugs used to generate general anesthesia have been used for many decades to patients of all ages without evidence of long-term damage. New evidence from animal research is accumulating in the field of anesthetic neurotoxicity *(10–12)*. According to their results, possibility of long lasting effects on the central nervous system might be expected. Infants and neonates are considered to be at greater risk due to immature nervous systems. Reaching definite information about the effects of anesthetics on the developing brain will probably take numerous animal and human studies during many years. These further studies need to answer many questions regarding the effects of anesthetics on neurologic development in children other than age, the use of specific anesthetic drugs and techniques, duration of exposure, doses and other factors. Currently there are no alternatives to the anesthetic drugs in use, but application of regional anesthesia when possible may be the best alternative.

Surgical trauma induces a stress response that has endocrine, metabolic, hormonal, immunologic and inflammatory consequences. All these factors lead to cellular and organ dysfunctions with long convalescence period, especially in children. Regional anesthesia was more effective in reducing surgical stress during surgery than systemic opioids *(13)*.

Respiratory complications during and after general anesthesia in babies are the other reason to practice regional anesthesia. Alveolar collapse, hypoxemia, apnea and bradycardia are significantly lower postoperative complications with regional blocks, than those who receive general anesthesia. Rate of ventilator support after anesthesia is also reduced, mostly in large surgeries, like thoracic, upper abdominal and cardiac anesthesia *(14, 15)*.

Analgesia is in other issue achieved with regional blocks. Acute pain causes chest and abdominal wall muscle splinting and result with decreased tidal volume and alveolar ventilation *(16)*. Pain in babies and small children has been ignored for many years, and usually was untreated. Quality of postoperative pain control possible with regional anesthesia and its minimal effect on cognitive function is difficult to realize with other methods. Neonates had lower pain scores and overdose with opioids could have fatal outcome *(17)*.

Caudal blocks and dorsal penile blocks are effective for circumcision performed in awake neonates. Ilioinguinal and rectus sheath blocks, transverses abdominal plane blocks and wound infiltration with local anesthetics is commonly performed in combination with general anesthesia. Spinal, epidural, and caudal routes are applied for with general anesthesia or in awake neonates *(18)*. The advantages include reduction of general anesthetic and opioid requirements, and the need for postoperative mechanical ventilation and other postoperative respiratory complications.

But still, when compared to adult regional anesthesia, regional anesthesia in children is relatively rarely done. According to a French survey, regional pediatric anesthesia represents 12% of the total anesthesia cases; infants represent 1%, and neonates or preterm babies are extremely rarely done *(19)*.

In regards with many studies and meta-analyses *(20–21)* is improved that epidural analgesia decrease the length of stay in hospital, decrease the complications, like respiratory complications, vascular and gastrointestinal complications, low the rate of nausea and vomiting in postoperative period.

CONTINUAL REGIONAL ANESTHESIA

Prolonged intraoperative and postoperative analgesia with continuous central or peripheral nerve block catheters (CCT) became the preferred technique in many pediatric centers. Duration of plain long acting local anesthetics is only 3–5 h, which is easily solved by this technique.

The indications to place a catheter for continuous peripheral nerve blocks are long and painful intraoperative procedures requiring postoperative pain control for many days. Postoperative rehabilitation and physiotherapy are probably the main indications, because only if pain is under control, the successful rehabilitation could be performed. Many published studies underline the efficacy and safety of analgesia via a peripheral catheter, and the low rate of complications or side effects. The stress response and postoperative complications is visibly decreased compared with systemic analgesia. They can affect outcome and the postoperative cost, intensive care unit and hospital stay is rapidly increased. The incidence of PONV is very low, but the bowel function is not impaired *(22).*

In neonates, epidural catheters inserted through the sacral hiatus can be advanced to a lumbar or thoracic level. This catheter allows the neonate to benefit from epidural analgesia without the worry of spinal cord injury *(23).* In the series of 15,013 central blocks; 29 of them was neuraxial catheters, the complication rate for 0±30-day-old term and preterm neonates was 0% *(19).*

The conduct of continual regional blocks in children by pediatric anesthesiologist carries only a small risk for neural damage *(19).*

LIMITATIONS OF REGIONAL ANESTHESIA IN CHILDREN

The anatomy of children differs from that of adults in the size and position of the spinal cord. At birth, the cord ends at L3 and the dura at S3; therefore, an injury to the spinal cord can occur when a lumbar epidural block is performed even at low levels. By the end of the first year of life, the cord and the dural sac rise to reach their adult levels, L1, L2 and S2. The loose epidural fat increases a spread of local anesthetics, up to the thoracic region. Up to the age of 6–8 years central nerve blocks, spinal and epidural, causes only minimal cardiovascular changes.

Myelination is not complete until 12 years of age. Incomplete myelination allows for better penetration of local anesthetic into the nerve fibers. Also, the loose of fascial attachments around the nerves increase the spread of local anesthetic. Furthermore, because the local anesthetic spreads easily in children, the duration of the block may be shortened compared to an adult. As the patient's age increases, local anesthetic latency of onset and duration of action increases as well *(24).*

Martin Jöhr *(25),* in his article presented at ESRA Winter Week 2010, described three phenomena which characterized the pharmacokinetics in neonates and small infants: firstly, a larger volume of distribution leading to lower plasma levels; secondly, an increased free non-protein bound fraction enhances toxicity and, thirdly, a diminished metabolic clearance. Low levels of α-1 acid glycoprotein lead to higher serum levels of unbound local anesthetic, and this free drug is responsible for toxicity. Infants also have decreased clearance and a longer elimination half-life of local anesthetic compared to adults. All these factors contribute to the increased general risk of local anesthetic toxicity resulting from a predominance of free drug circulating in the pediatric patient's plasma during regional anesthesia.

Absolute contraindications for spinal anesthesia in children include refusal of the parents, coagulation defects, and infection at the site of insertion, true allergy to local anesthetics, severe hypovolemia, progressive neurologic disease and uncontrolled convulsions *(26).*

The French-Language Society of Pediatric Anesthesiologists *(19)* reports the results during the one year period. From 85,412 procedures; 61,003 were realized with general anesthesia and only in 24,409 cases were performed regional anesthesia. Most of the blocks were caudal (15,013 or more than 60%), and the other part included different regional techniques. Most of the blocks were performed under light anesthesia. Complications were rare and minor, without any sequel. The overall complications rate of regional anesthesia was 0.9 in 1000, but complications occurred with central blocks were 1.5 in 1000.

The incidence of complications during regional anesthesia is relatively low.

CONCLUSIONS

Regional anesthesia could not replace the general anesthesia in children. But, the high benefits and extremely low incidence of complications during regional anesthesia must support anesthesiologists to use them more frequently.

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