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The use of perineural catheters in pediatric population

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Abstract. *Perineural catheters (PCs) provide prolonged effect of the peripheral nerve block, and through a percutaneously placed catheter, whose top is near the nerve or nerve plaxus, local anesthetic is titrated to the desired effect. Catheter placement is performed under the control of ultrasound and / or neurostimulator. After placement, tunneling is carried out to ensure the adequate position of the catheter. PCs can be placed on the upper extremities (an extended block of the brachial plexus using an interscalene, supra/infra-clavicular or axillary nerve approach), lower extremities (prolonged lumbosacral plexus block, femoral, ischiadic or popliteal block) and other perineural blocks (thoracic, ilioinguinal, paravertebral, tap etc.) PCs have an increasing implementation on pediatric patients with aim to provide intraoperative anesthesia, postoperative analgesia and chronic pain therapy. Numerous studies on pediatric patients have shown that perineural catheters improve control of postoperative pain and lead to reduced use of opioids, thereby reducing the risk of side effects. The most common use of PCs is in orthopedic surgeries, where they significantly regulate postoperative pain and allow early use of physical therapy, better post-operative recovery, and reduce time of hospitalization. With adequate training of parents, they can be used at home. Due to the small number of contraindications (allergic reaction to local anesthetics, infection on the site of placement, patient refusal), and improvements in clinical, economic and humanistic approach, PCs have an increasingly important application. PCs improve the control of post-operative pain, reduce the use of analgesics and opioids, reduce post-operative complications nausea and vomiting, reduce time spend in hospital, require less treatment costs and improve the satisfaction of children and their parents.*

Key words: *perineural catheters, children, regional anesthesia, pain management*

Perineural catheters (PCs) provide prolonged effect of the peripheral nerve block through a percutaneously placed catheter, whose tip is near the nerve or nerve plexus. A local anesthetic is titrated to the desired effect through the catheter (1).

PCs are used increasingly in pediatric patients in order to provide intraoperative and postoperative analgesia and as chronic pain therapy. Their widest application is in orthopedic, plastic and vascular surgery as well as in the treatment of pain in haemathological and oncology patients (2).

A large number of surgical interventions can be done under conditions of analgosedation. Analgesia can be provided by applying the appropriate regional anesthesia technique. In children, regional anesthesia is mostly used under conditions of general anesthesia.

Absolute contraindications for placement of PCs are: allergy to local anesthetic and infection at the site of planned puncture. Relative contraindications are sepsis, prolonged PT and PTT, heart failure, respiratory pathology, neurological diseases and patient refusal. Due to the small number of contraindications and improvements in the clinical, economic and humanistic approach, PCs are used more often nowadays (3).

Catheter placement is performed under the supervision of ultrasound (US) and/or nerve stimulator (NS). NS causes muscular contractions of the corresponding muscle group and in this way we can confirm the correct position of the needle and identify the required nerve structures. The US works by transmitting ultrasonic waves that are reflected from the obstacle and according to the time required to return the wave, the distance and shape of the structure are determined. Placement of PCs under the control of ultrasound is becoming more and more frequent and has an increasingly wider use nowadays (4, 5). Advantages of using US are reflected in the fact that it is possible to monitor the path of anatomical structures to achieve a safe orientation. The latest US devices allow visualization of the needle itself and in that way they ensure the best position of the needle in relation to the anatomical structures, reduce the risk of nerve injury and surrounding structures and allow visual-

isation of intravenous injection of local anesthetics. US enables monitoring of the distribution of local anesthetics and in that way optimizes the amount of local anesthetics which reduces the risk of toxic reactions. This fact is especially useful in countries where opioid use is very limited, since PCs are then used as the only analgesic technique (6).

So far, the largest study on the safety of PCs use in children has been published in 2015. The observational study used a regional database of over 2000 set up PCs in children. The data demonstrated a low degree of complication, which is correlated with the percentage of complications in the adult population (7).

The most common complication is infection: local inflammation at the site of catheter placement (redness, swelling or pain) and abscess at the catheter insertion site. Studies have shown that PCs infections are a rare occurrence and that the incidence is in correlation with the time that has passed since the catheter is placed (7, 8, 9). It is considered that the PCs should be removed 3 days after the placement which reduces complications to a minimum (7), except in cases where the benefits to the patient overcomes the clinical risk of infection.

After adequate positioning of the patient and determination of anatomical structures with the NS and/or US, the skin shoud be desinfected and after the needle placement the catheter is pulled through the needle through its tip. The needle must be slowly pulled, then the catheter is fixed, the bacterial filter is placed and after the aspiration the test dose of the local anesthetic is given. After placement, tunneling is being carried out to ensure the adequate position of the catheter.

PCs can be placed on the upper extremities (an extended block of the brachial plexus using an interscalene, supra/infra-clavicular or axillary nerve approach), lower extremities (prolonged lumbosacral plexus block, femoral, ischiadic or popliteal block) and other perineural blocks (thoracic, ilioinguinal, paravertebral, tap etc.)

Continuous perineural blocks of the upper extremities

When PCs are placed in the upper extremities, the most commonly used approach is axillary, then interscaline, supraclavicular and rarely infraclavicular approach (10).

In the case of interscalene approach, the patient's hand is in the supination position with a head turned at angle of 45 degrees in the contralateral side. Indications are operations of the shoulder, clavicle, upper arm, reposition of the shoulder joint luxation and pain therapy for the this regions. The NS puncture site is in the interscalene space, which corresponds to the level of C6 vertebra and cricoid cartilage respectively (11). The US scanning of the neck with a linear sound begins at the level of cricoid cartilage. Lateral of the carotid artery is the intern jugular vein. Laterally from the vein is muscle scalenus anterior. Visualization of the nerve roots or truncus is in the transverse axis, so the nerves can be seen in the interscalene space as a hypoehogenic, circular or oval formations placed between the front and the middle of scalenus muscle.

In the supraclavicular approach, arm of the patient is positioned in the supination position with a head turned at the angle of 45 degrees in the contralateral side. Indications are surgery of the upper arm, forearm, hand and pain therapy in these regions. The NS puncture point is placed posteriorly and laterally from the place corresponding to the middle of the clavicle, where the pulsations of the subclavian artery can be palpated.

The US device is placed in the fossa supraclavicularis and the region is scanned with the linear probe medially towards laterally (12). The subclavian artery and plexus brachialis lie on the first rib in a common neurovascular layer, with the plexus brachialis placed posteriorly and laterally to the subclavian artery. Its structure looks like a cluster. Subclavian vein and muscle scalenus anterior are placed medially from the subclavian artery. Pleura is located very close to the brachial plexus. Complications of PCs placement can be punction of the subclavian artery, pneumothorax, stellate ganglion block, phrenic nerve block and haemathoma.

Indications for the infra-clavicular approach are analgesia from the shoulder to the hand and pain therapy for this regions which includes nerve musculocutaneus. NS puncture point is in the middle of the clavicle and the axillary artery but this approach is rarely used in children.

The axillary approach aims to block the terminal branches of the plexus brachialis, which implies median, ulnar,radial and musculocutaneous nerve which often remains unaffected by this approach. The nerves are placed just beside the axillar artery and surrounded by muscle biceps brachii, coracobrachialis and triceps brachii. Indications for this approach is surgery of the forearm and hand as well as pain therapy in this region. The patient's position is in supination with abduction of arm at an angle of 90 degrees. The NS orientation point is axillary artery in the most medial and the highest point. With the US approach, we scan the axillar region and identify the axillar artery. It is necessary to perform a slight pressure with the ultrasound probe in order to deliberate compression of axillary veins and prevent accidental intravascular injection of the local anaesthetic (13). The nerves look like honeycomb due to the mixed composition of this region, the hypoehogenic (nerve layers) and hyperehogenic (connective tissue) round and oval structures.

Continuous perineural blocks of the lower extremities

The nerve structures of the plexus lumbalis pass in front of the hip joint and innervate most of the front side of the thigh. The most common approach for the plexus lumbalis block is Winnies approach, when the patient is lying on the side, the affected leg placed up, with the flexion of legs in the hip and knees.

The place of puncture is the cut point of two lines, intercristal line and the line parallel to the spinous processions which passes through the spina iliaca superior posterior. The needle should be directed slightly medially. The expected motor response to nerve stimulation is contraction of the quadriceps muscle. Indications for this approach are hip, femur and knee surgery and pain therapy in these regions. Complications are rare but dangerous: direct trauma of the nerves, intraneural and intravascular injection of local anesthetics, retroperitoneal hematoma, kidney injury, abscess formation in the muscle, epidural/spinal expansion. Femoral nerve is the largest terminal branch of the lumbar plexus which enters the thigh beneath the inguinal ligament, laterally from the artery femoralis, deep to the fascia iliaca and superficially in relation to the iliopsoas muscle. Anterior approach in blocking the femoral nerve is performed in the inguinal region and it is suitable for femur and knee surgery. The patient's position is in

supination, with a leg in a neutral position. The NS punction point is caudal from the point of intersextion of the lateral and middle third of the inguinal ligament. During needle puncture, two pops should be felt when passing the needle through a fascia lata and fascia iliacca. The aim is to achieve a contraction of quadriceps muscle which is seen as dancing patella phenomenon. With the US approach, the first necessary thing is to identify femoral artery. Femoral nerve is seen as a triangular-shaped hyperehogenic structure, lateral from the femoral artery and above iliopsoas muscle. Hyperehogenic line that represents the fascia iliaca can also be seen. Needle access can be in plane or out of plane. By injection of a small volume of local anesthetics, the expansion of hypoechogenic fluid that surrounds the femoral nerve can be seen (14).

Plexus sacralis is build from the front branches of the L4, L5, S1–S4 spinal nerves. It provides motor and sensory innervation of the back of the thigh, the largest part of the lower leg, foot and part of the pelvis. It is part of the plexus lumbosacralis.

Continuous blockage of ischiatic nerve can be performed by a posterior approach (Labat) when the patient's position is on the side with a leg that is blocked bent in the knee at the angle of 90 degrees and the hip bent at 40 degrees. The orientation points are spina iliaca posterior superior, trochanter major and hiatus sacralis. Puncture point is located at the cross-section of two virtual lines at the angle of 90 degrees. The first orientation line is between the large trochanter and spina iliaca superior posterior and the second one is between the large trochanter and the sacral hiatus. The expected answer to nerve stimulation is flexion and extension of the feet and toes of the foot.

Ischiatic nerve is divided into common peroneal nerve and tibialis nerve at the top of the popliteal fossa. In posterior approach, the patient's position is with a slightly flexed leg so that we can palpate the top of the popliteal fossa. US in many ways makes it easier to find anatomical structures and visualize them clearly. It is necessary to identify the femur and then the popliteal artery as a pulsating structure located superficially in relation to the femur. The popliteal vein can sometimes be challenging to identify because it is very easily collapsed when pressed with the ultrasound probe. The hyperehogenic structure of the ischiadic nerve is always localized laterally from the popliteal artery. What we need to achieve is to scan the path of the ischiatic nerve and locate the site of branching to tibial and peroneal nerves (15).

Numerous studies in pediatric patients have shown that PCs improve postoperative pain control and lead to reduced use of opioids, thereby reduce the risk of opioids side effects (16, 17). The most common use of the PCs is in major orthopedic surgery because it significantly reduces postoperative pain,enables early physical treatment, better postoperative recovery and shortens hospitalization (18).

With adequate training of parents PCs can be used at home. The use of home catheters has become a common practice in adult patients after major orthopedic surgery (19). Use in pediatric patients proved to be an effective tool in providing postoperative analgesia, with the low level of nausea and vomiting and without serious complications (20, 21). Although regional anesthesia is very effective in providing postoperative analgesia, a single bolus provides only 8–12 hours of analgesia. Large orthopedic procedures can lead to acute postoperative pain for 2–3 days, in which case the use of PCs is very useful for providing longer postoperative analgesia (22).

Use of PCs improves the control of postoperative pain, reduces the use of analgetics and opioids, postoperative nausea and vomiting, time spent in the hospital as well as costs and improves the satisfaction of children and their parents.

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Використання перинервальних катетерів у дитячого населення

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Резюме. *Перинервальні катетери (ПК) забезпечують пролонгованість дії периферичних нервових блокад та, завдяки перкутантному розміщенню катетера, кінець якого розташовується поруч з нервом або нервовим сплетенням, титрування місцевого анестетику здійснюється до досягнення бажаного ефекту. Постановка катетера виконується під контролем ультразвуку та/або нейростимулятора. Після розміщення провідник виводять для того, щоб упевнитися у правильності позиції катетера. ПК можна встановлювати на верхніх кінцівках (провідникова анестезія плечового сплетення, використовуючи доступи через підлопатковий, над- і підключичні та аксилярні нерви), нижніх кінцівках (подовжені блокада попереково-крижового сплетення, стегнова, сіднична та підколінна блокада) та при інших перинервальних блоках (грудний, клубово-пахвинний, паравертебральний, блок нервів передньої черевної стінки (тар-блок) тощо). Зростає використання ПК серед педіатричних пацієнтів з метою здійснення інтраопераційної анестезії, післяопераційної аналгезії та для лікування хронічного болю. Численні спостереження за педіатричними пацієнтами показали, що використання перинервальних катетерів підвищує контроль післяопераційного болю та скорочує використання опіоїдів, тим самим зменшуючи ризик побічних ефектів. Найчастіше ПК використовують під час ортопедичних хірургічних втручань, оскільки вони значно регулюють виникнення болю у післяопераційному періоді та дозволяють раннє використання фізіотерапії, покращують післяопераційне відновлення та зменшують тривалість госпіталізації. Після правильного навчання батьків катетери можна використовувати амбулаторно. У зв'язку з незначною кількістю протипоказань (алергійна реакція на місцеві анестетики, інфекційні прояви на стороні встановлення катетера, відмова пацієнта) і покращенням клінічного, економічного та соціального підходу, важливість використання ПК зростає. ПК підвищують контроль післяопераційного болю, обмежують використання анальгетиків та опіоїдів, знижують післяопераційні ускладнення, такі як нудота і блювання, скорочують час перебування у лікарні, забезпечують дешевше лікування та збільшують задоволеність дітей та їхніх батьків.*

Ключові слова: *перинервальні катетери, діти, регіонарна анестезія, лікування болю*

Использование перинервальных катетеров у детского населения

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Резюме. *Перинервальные катетеры (ПК) обеспечивают пролонгированный эффект периферической нервной блокады и, благодаря перкутанному размещению катетера, кончик которого располагается вблизи к нерву или нервному сплетению, местные анестетики титрируют к достижению желаемого эффекта. Размещение катетера производится под контролем ультразвука и/или нейростиммулятора. После постановки, проводник вынимается для того, чтобы убедится в правильности позиции катетера. ПК можно устанавливать на верхние конечности (расширенная блокада плечевого сплетения, используя подлопаточный, над- и подключичные или аксиллярные нервные доступы), нижние конечности (пролонгированная блокада поперечно-крестцового сплетения, бедренный, ягодичный и подколенный блок) и при других перинервальных блоках (грудной, подзвдошно-паховый, паравертебральный, блок нервов передней брюшной стенки и т д.). ПК все больше используют у педиатрических пациентов с целью обеспечить интраоперативную анестезию, постоперативную аналгезию и терапию хронической боли. Множественные наблюдения за педиатрическими пациентами показали, что ПК улучшают контроль боли в послеоперационном периоде и обеспечивают снижение использования опиоидов, тем самым уменьшая риск побочных эффектов. Более часто ПК используются при ортопедических операциях, так как они значительно регулируют послеоперационную боль и позволяют использовать физиотерапию, обеспечивают лучшее восстановление после хирургических вмешательств и сокращают время госпитализации. При адекватном обучении родителей катетеры можно использовать амбулаторно. В связи с малым количеством противопоказаний (аллергическая реакция на местные анестетики, инфекционное поражение на стороне постановки катетера, отказ пациента) и улучшением клинического, экономического и гуманного подхода, ПК повышают контроль послеоперационной боли, уменьшают использование опиоидов и анальгетиков, уменьшают количество послеоперационных осложнений, таких как тошнота и рвота, сокращают время пребывания в больнице, требуют меньшего количества средств на лечение, повышают удовлетворение детей и их родителей.*

Ключевые слова: *перинервальные катетеры, дети, регионарная анестезия, лечение боли*