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PERIPHERAL NERVE BLOCKS FOR KNEE-SURGERY

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ПЕРИФЕРИЧЕСКИЕ НЕРВНЫЕ БЛОКАДЫ ПРИ ХИРУРГИИ КОЛЕННОГО СУСТАВА

Цель данной работы — анализ современных методов периферических нервных блокад (ПНБ) при хирургических вмешательствах на коленном суставе. В статье показана десятилетняя эволюция от эпидуральной анестезии до блокад, сохраняющих двигательную активность. Хирургические вмешательства на коленном суставе могут быть выполнены под общим наркозом, нейроаксиальной блокадой или их комбинацией. Недостатки эпидуральной анестезии вызвали снижение своего доминирующего положения в региональной анестезии. Различные ПНБ нижней конечности используются для операций на коленном суставе. Также ПНБ является одним из ключевых элементов мультимодальной анальгезии. Блокада бедренного нерва считается «золотым стандартом» послеоперационной анальгезии после тотального эндопротезирования коленного сустава. В последнее время растет интерес к сохранению мышечной силы четырехглавой мышцы после хирургических вмешательств на коленном суставе, что приводит к улучшению качества реабилитации у этой категории больных. Блокада бедренного нерва может быть хорошим вариантом для этих целей. Другие ПНБ, при которых сохраняется моторная функция, будут рассмотрены далее.

Вывод. Современная местная анестезия имеет в своем арсенале различные методы, которые могут быть использованы в зависимости от потребностей пациента, хирурга, анестезиолога и медицинского обслуживания.

Ключевые слова: хирургия коленного сустава, периферические невральные блокады, блокада бедренного нерва.

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The aim of this article is to conduct an analysis of modern methods of peripheral nerve blocks (PNB) in knee-surgery. In this article an evolution from epidural anesthesia to motor-sparing blocks during last decades will be shown. Knee-surgeries can be performed under general anesthesia, neuraxial anesthesia, PNB or their combination. The drawbacks of epidural anesthesia caused decreasing of its dominant position in regional anaesthesia. Different PNBs of lower limb are used for knee-surgeries. They have become a key element of multimodal analgesia. Femoral nerve block is considered to be a gold standard of postoperative analgesia after total knee-arthroplasty. Recently, the growing interest to preserve quadriceps muscle strength after major-knee surgery was observed. Avoidance of quadriceps weakness enhances rehabilitation. Adductor canal block may be good option for these objectives. Other motor sparing blocks will be examined further.

Conclusion. Modern regional anaesthesia has got different methods, which can be used depending on the needs of patient, surgeon, anaesthetist and health service.

Key words: knee-surgery, peripheral nerve blocks, femoral nerve block.

Introduction

The benefits of RA have been well-known for several decades. Such results had their pathophysiological background and the justification in the afferent blockade. Advantages of RA stem from a direct positive impact on the functioning of organs and homeostasis in the stage of perioperative stress. Afferent neural blockade improves tissue perfusion, decreases insulin resistance, attenuates proinflammatory resistance, creates optimal pain relief, increases gut motility, attenuates endocrine stress response, minimalizes inhibition diaphragmatic activity and increases coronary perfusion (Carli et al., 2011).

Decreasing Role of Epidural Anaesthesia

Rodgers in his meta-analysis showed the impact of regional anaesthesia for reduction of perioperative mortality and morbidity (Rodgers et al., 2000). Immediately after the publication of Rodger's meta-analysis, several critical comments appeared, emphasizing the inaccuracy regarding the primary above-mentioned outcomes. The reduction of morbidity and mortality by cardiovascular diseases has not been confirmed in majority of recent studies. They revealed only the effect of reducing the incidence of supraventricular tachycardia (Svircevic et al., 2011). Adoption of minimally invasive surgical techniques (Joshi et al., 2013), less optimistic results of contemporary meta-analyses (Liu et al., 2007), widespread use of prophylactic anticoagulant regimens (Vandermeulen et al. 2010), litigation concerns (Neal et al., 2012) and implementation of fast-track postoperative rehabilitation strategies (Carli et al., 2011) were reasons to decrease of neuraxial blockade using. The comparison of epidural blockade with systemic using of opioids demonstrates lesser dynamic pain in the epidural group (Rawal, 2012). The drawbacks of epidural analgesia involve frequent hypotension, urinary retention and pruritus (Fowler et al., 2008). Systemic opioids caused more sedation. Moreover, degenerative spinal changes and anticoagulant therapy increases risk of dramatic neurological complications after total knee arthroplasty because of epidural blockade (Neal et al., 2012). An alternative to epidural anaesthesia among regional anaesthesia techniques is peripheral nerve block (PNB) of one or more major nerves (Al.-Haddad et al., 2003).

Diversification of PNB

While discussing the topic of PNB, we must remember to distinguish between surgical anaesthesia, surgical analgesia and postoperative analgesia. With surgical anaesthesia PNB is the main and single component of anaesthesia. Surgical analgesia with PNB is connected to the so-called light general anaesthesia. Postoperative analgesia with PNB is the crucial element of the multimodal analgesia.

Outline of knee innervation

A working knowledge of the appropriate anatomy is necessary for nerve localisation and successful PNB block. Combining lumbar plexus block with sciatic nerve block may provide anaesthesia for most lower limb procedures and also for knee-surgeries (Kalum et al., 2008). Single nerve block can often be used to result in effective and useful postoperative analgesia. Innervation of the knee joint is derived from femoral nerve via the branch to vastus medialis (anterior aspect of the joint capsule); sciatic nerve via genicular branches of both tibial and common peroneal components (posterior aspect of the joint capsule and all of the intra-articular structures); and obturator nerve by a branch from its posterior division. The latter accompanies the femoral artery through adductor magnus into the popliteal fossa. Cutaneous innervation of the anterior aspect of the knee is supplied by the femoral nerve. Additionally, cutaneous innervation of lateral aspect is supplied by the lateral femoral cutaneous nerve (Enneking et al., 2005). The obturator nerve innervates the skin on the medial aspect of the knee in less than 40% of people and area of obturator sensor innervation is variable (Enneking et al., 2005).

Anatomical consideration of adductor canal block

The running of neural branches into adductor canal has been subjected to a few investigations in the last years. The saphenous nerve is a sensory branch of the femoral nerve. It innervates the skin over the medial, anteromedial, and posteromedial aspect of the lower limb from above the knee to the foot. Thus, blockade of the saphenous nerve produces anaesthesia and analgesia of the anteromedial aspect of the lower leg, ankle, and foot, but without producing quadriceps muscle weakness. (Horn et al., 2009).

Saphenous nerve block is commonly used with a sciatic nerve block to provide a complete anesthesia and analgesia of the lower leg below knee. Its small size and lack of a motor component makes it difficult to localize the conventional nerve identification techniques. Hereby, ultrasound guidance increases the success rate of blocking this nerve (Saranteas, 2011; Minickam et al., 2009). The saphenous nerve is a terminal branch of the femoral nerve, leaving the femoral canal proximally in the femoral triangle, descending within the adductor canal, and remaining deep to the sartorius muscle with the femoral artery (Horn et al., 2009). It is initially found lateral to the femoral artery, and then becomes more medial and superior to the vessel at the distal end of the adductor magnus muscle. Davis and others demonstrated that 30 ml of dye injected at the adductor canal can reach the anterior and posterior division of the femoral canal. (Davis et al., 2009) This injection of pigment into the adductor canal in a cadaver with 15-cm spread both proximally and distally.

Moreover, there is no boundary between the apex of the femoral triangle and the adductor canal (Ishiguro et al., 2012). It is believed that local anesthetic can spread easier to femoral triangle, where run more femoral nerve branches, especially, with high volume and pressure (J. Chen et al., 2014). Other authors (Cowlishaw et al. 2015) observed the dye down from apex of femoral triangle to adductor hiatus. This fact explains clinical findings (P. Jaeger et al., 2013) showing successful postoperative analgesia for knee-surgery with protection of quadriceps force. Number of publications concerning the ACB (adductor canal block) is trying to clarify the topographic anatomy saphenous nerve in the femoral triangle and the adductor canal in the context of defining a suitable point of entry of the needle, end-point of the needle and spreading local anaesthetic. The purpose is to avoid blocking motor branches of femoral nerve leaving proximal adductor canal (Bendtsen et al., 2015).

The lateral femoral cutaneous nerve (LFCN), the intermediate cutaneous nerve of the thigh (IMCNT) and the infrapatellar nerve (IPN) innervate the skin of the knee (Enneking, 2005.; Egeler, 2012). Additionally, the IPN and the genicular branches of the sciatic, obturator and femoral nerves contribute to the knee joint innervation. The anatomical location of these nerves can be identified using ultrasound. The LFCN and IMCNT traverse the sartorius muscle within the femoral triangle. The IPN runs medially around or through the sartorius muscle, but is reliably blocked in the subsartorial canal at mid-thigh level. Selective neural blockade of the IPN could, thus, have the potential for providing clinically significant supplemental analgesia in this context as the majority of arthroscopic surgery involves manipulations within the territory that is supplied by this nerve (Lundblat et al., 2006). The genicular branches are identified deep to vastus medialis and lateralis at the level of the femoral epicondyles, with the inferior genicular branch located medial to the tibial plateau. Descending geniculary artery is good sonoanatomical landmark for injection of local anesthetic when selective sensor block is desirable (Horn et al., 2009).

Comparison of neuraxial blockade to PNB

During past decades EA was the method of choice for majority of hip and knee surgeries. Currently, however, every once we rarely find indications for major knee-surgery under epidural anesthesia. Revision of knee — prothesis and bilateral knee prosthesis

stay the exception and is performed with epidural analgesia (Stundner et al., 2012). Neurological complications occur more frequently in cases of patients with EA undergone TKA (total knee arthroplasty) (Moen et al. 2004). The risk of epidural haematoma is greater in this group of patients. Comparative meta-analisys EA and peripheral nerve block (PNB) by major knee-surgery revealed (Fowler et al., 2008) the same postoperative pain-relieve profil, more prone to hypotension and other side effects like urinary retention, delayed ambulation (Capdevila et al., 1999) in the EA group. The authors of these meta-analisys suggested that EA should not be used in routine clinical practise and PNB is the method of choice after major knee surgery (Fowler et al., 2008).

Posterior Lumbar Plexus Block with Knee Surgery

At first glance, LPB (lumbar plexus block) or PCB (psoas compartment block) should be selected from the methods of lower limb PNB in the knee-surgery. LPB can be performed from posterior approach (Aldahish, 2004), anterior approach — 3 in 1 method and FIB (fascia-iliaca block). Posterior approach LPB is more invasive than anterior approach (Fowler et al., 2008). Approximately 10% cases of PCB occur epidural spreading of local anesthetic with not indenting epidural analgesia(Enneking et al., 2005). Renal haematoma (Simihisa,et al. 1996) and retroperitoneal haematoma (Weller et all. 2003) were described. Furthermore, by this block like by other deep blocks with perioperative thromboprophylaxis, caution is mandatory (Narouze et al., 2015) . This block is not recommended by Working Group PROSPECT like method of choice in TKA (Prospect, 2008) . The same point of view is shared by other authors. The authors of meta-analisys (Touray et al., 2008) assessed psoas compartment block plus sciatic nerve block for surgical anesthesia and PCB in postoperative analgesia. They concluded that PCB with sciatic nerve block is equivalent to general anaesthesia and spinal anesthesia for knee-arthroscopy. However there are not strong evidences to use this blocks like alternative for general anesthesia or neuraxial anesthesia. Additionally, this authors claimed that PCB in postoperative analgesia for TKA and knee-arthroscopy is comparable with intravenous opioids and with epidural analgesia. On the other hand, there is no difference between PCB and femoral nerve block with simultaneous better risk — benefit profile for femoral nerve block. This fact limits use of PCB in intra- and postooperative period by knee-surgery.

Femoral Nerve Block with Knee Surgery

Femoral nerve block after TKA is effective as the posterior approach LPB and is related with fewer side-effects. Block can be performed with anatomical landmark Winnie perivascular approach elicited paresthesia (Enneking, 2005). Paresthesia method was replaced by PNS (peripheral neurostimulation) and by ultrasound guidance in last years (F. V. Salinas, 2016; J. Kessler et al. 2015). Elicitation of quadriceps muscle response requires specific attention. Sartoris muscle's response with PNS may be mistakenly interpreted as a location close to femoral nerve. Motor branches of femoral block immediately move away from femoral nerve below inguinal ligament. During identification of femoral nerve the first response is sartorius muscle contraction. In this case this response should be ignored and needle needs to be inserted some deeply and laterally The role of PNS has changed after implementation of ultrasound in the RA. Nowadays, PNS is used like a part of triple monitoring method which includes a combination of ultrasound guidance, PNS and pressure monitoring in order to avoid intrafascicular location tip of needle and neural injury (J. Neal et al., 2015).

Ultrasound-guide femoral nerve block is performed with high-frequency linear probe in the short-axis. The nerve is visible like a triangular hyperechoic area which lies 1–2 cm laterally to the artery under the fascia lata and the fascia iliaca on the anterior aspect of the iliopsoas muscle (M. Fingerman et al., 2009). Its visualisation sometimes is difficult and the nerve has a biconvex or oval shape like a hyperechoic structure (D. Ghisi et al.,

2014). Anatomic variations of the femoral nerve in the inguinal region are rare and include femoral nerve located immediately adjacent to the posterolateral aspect of the femoral artery or location into iliopsoas muscle (Ki Jinn Chin et al., 2011). Ultrasound guide femoral nerve block has evolved in optimal and dominant peripheral nerve method, when compared with nerve stimulation technique, which improves block onset time, block performance time and quality of block (F. V. Salinas, 2016) .

As was mentioned previously, the femoral nerve together with contributions from the sciatic and obturator nerves at the posterior and medial aspects, respectively, provide sensory innervation of the knee. They are the three terminal nerves which are targeted by PNB techniques for major knee surgery (Fowler et al., 2008). PROSPECT Working Group recommends femoral nerve block for TKA with GA (general anaesthesia) or with spinal anaesthesia or with spinal local anaesthetic plus morphine (not as a first choice) (Prospect, 2008). It is discussed whether an in-plane or out-of-plane needle-probe with short-axis is preferable for femoral perineural catheter. The advantage of the in-plane technique is better needle tip precision through real-time observation of the needle shaft and tip. Advantages of the out-of-plane approach include, however, a needle orientation more consistent with the long-axis of the nerve and adjacent muscle/fascia. Orientation of the needle more in line with the nerve may facilitate catheter insertion in addition to keeping the catheter close to the nerve. The authors of study (Fredrickson M et al. 2013) did not find any evidence to support the superiority of either the in-plane or out-of-plane needle-probe alignment techniques for femoral nerve catheter placement. The results suggest that for two methods plane needle-probe alignment for femoral catheter placement, anesthetists should use the approach with which they are more familiar and which they frequently use. Moreover, oblique out-of-plane needle probe with short-axis is recommended for continuous femoral nerve block (Fredrickson, 2008).

For continuous femoral nerve block after major knee-surgery were proposed different methods strategy of infusion. There are three basic regimens to provide continuous peripheral nerve block analgesia: fixed basal rate, fixed basal rate plus bolus doses, or boluses only (Boezaart, 2006). The latter two regimens can be defined as patient-controlled regional analgesia (PCRA) systems. Some authors (Chelly et al., 2010) recommend initial bolus 6–12 ml ropivacaine 0.2 % with continuous infusion ropivacaine 0.1–0.2 % — 3–8 ml/h. Other authors (Aguirre et al., 2012) use Ropivacaine 0.2 % or Bupivacaine 0.125% with basal rate 3–6 ml/h, bolus: 2–4 ml and lockout-time 20–30 min.

Addition Sciatic Nerve Block to FNB after TKA

Sciatic nerve block (SNB) adding to femoral nerve block in the setting of TKA has been discussed for many years. Different effective technique of analgesia to the posterior knee after TKA were described: proximal sciatic nerve with trans-, infra-, sub-gluteal and lateral approaches, mid-femoral, distal SNB at the level of the popliteal fossa, isolated tibial nerve block, posterior knee capsular injection between Popliteal Artery and the Capsule of the posterior Knee-i-PACK technique (Elliot et al., 2015). Some investigators support single-use sciatic nerve block adding to FNB or ACB. While other investigators have suggested that sciatic nerve block is not clinically important after TKA suggesting to perform local infiltration analgesia of posterior knee. The jury is still out and future studies are guaranteed (Abdalah et al., 2014).

ACB in Clinical Practice

Growing amount of studies in the last years is dedicated adductor canal block after TKA. The ethology of quadriceps weakness is not fully understood. Pain, swelling, reflex inhibition after TKA impair quadriceps function. FNB, acting on the motor branches, does not spare motor function. ACB is performed in the centre of middle part of thigh with ultrasound, preserves muscle strength and probably facilitates early mobilization (P. Jaeger et al., 2014). ACB does not demonstrate inferiority in morphine consumption

when was comprised with FNB after TKA (P. Jaeger et al., 2013). Future studies will probably determine clinical efficacy, proper point of needle insertion, volume of local anaesthetic, the possibility of using continous block, impact on the early ambulation.

Other Blocks with Knee Surgery

The distal blocks like infrapatellar block after knee arthroscopy were not investigated in the clinical setting (Lindblat et al., 2006). Other motor-sparing block for postoperative analgesia includes 3 cutaneous branches block: IMCNT, LFCN, IPN plus block of 3–4 main genicular nerves — knee-joint branches of sciatic, common fibular, obturator and femoral nerves (Egeler et al., 2013). Main locations of those nerves are superomedial, superolateral and inferomedial part of the knee joint.

For surgical anesthesia during knee-surgery can be performed multiple nerve lower — limb block. The quadriple ultrasound nerve block is dedicated for the knee-arthroscopy and includes block of four nerves some caudally to inguinal ligament: femoral nerve, LFCN, anterior branch of obturator nerve and posterior of branch of obturator nerve. For anterior crucial ligament reconstruction is needed to add anterior sciatic nerve block — quantiple block (Borglum, 2011). The time necessary to perform the USG blocks prior to surgery was only 6–24 minutes. Obviously, performing of this blocks should be to confronted with various factors.

Conclusion

Regional anesthesia has important role in the knee-surgery and has to be tailored to the needs the patient, the surgeon, anaesthetists' experience and operating theatre schedule. Nowadays, modern regional anesthesia has got different methods in its armamentarium. Peripheral nerve block (PNB) in the knee-surgery and its evolution during last years is good example of the realization of the P. Marhofer's paradigm: "We should perform the block as centrally as necessary and as peripherally as possible" (Borglum, 2011). Ideal PNB in the knee-surgery should provide fast onset and dense surgical anesthesia, be simple, cost-effective and free of complications and adverse effects, allow to avoid general anesthesia if this is in interest of patient, enhance rehabilitation, decrease long of stay in hospital (Galitzine, 2015). The best method for knee-surgery has not been determined and future studies are guaranteed.

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