Scientific Research Publishing

Reducing the Dose of Local Anesthetic Reduces the Duration of Analgesia—Myth or Reality: A Double-Blind Randomized Study

Piacherski Valery, Marachkou Aliaksei

Department of Anesthesiology and Intensive Care, Health Care Institution "Mogilev Regional Hospital", Mogilev, Republic of Belarus
Email: pechersky.v@yandex.ru

Abstract

Background: The aim of the study is to determine the effect of a reduction in dose of local anesthetic blockade on the development of the sciatic nerve. Methods: Forty blocks of sciatic nerve were used in a double-blind randomized research, under ultrasonic guidance, using an electric stimulator with the peripheral nerves. Forty patients were divided into 2 equal groups. In the first group, a sciatic nerve block was performed with 5 ml of 0.75% ropivacaine solution (37.5 mg); in the second group, 10 ml of 0.75% ropivacaine solution (75 mg) was used. The assessment of the time required for developing sensory and motor blocks was carried out from the beginning of local anesthetic solution injection in the fascial sheath of the sciatic nerve. Results: Demographic data of patients were identical in the two sample groups. The time required for achieving a complete sensory block in groups treated with 5 and 10 ml ropivacaine was 45 (40; 48) and 30 (28; 30) min, respectively, (p < 0.01). There was no difference in analgesic duration in the postoperative period among groups at p > 0.05. Conclusions: Complete blockade of the sciatic nerve is developed using 5 ml of 0.75% ropivacaine. Reducing the dose of ropivacaine prolongs the latent period of the LA during the blockade of the sciatic nerve. Time of postoperative analgesia was not significantly changed.

1. Introduction

An anesthetist's arsenal includes several local anesthetics for carrying out regional anesthesia, and these anes-

thetics require different times for achieving complete sensory and motor blocks as well as different acting times [1]; attempts to mix anesthetics with different properties were done earlier with the aim of summarizing their useful effects. The toxic action of local anesthetics, appearing as a result of unpremeditated intravascular injection as well as a result of preparation absorption, required research in order to identify low doses of local anesthetics for effectively blocking peripheral nerves [2]. Different local anesthetics with different durations of action are used to block the sciatic nerve [1] [2]. The latter fact is of great importance not only for duration of surgery, but also for postoperative analgesia. Ropivacaine has the longest period of analgesia. Blockade of the sciatic nerve performs 10 - 40 ml of 0.75% ropivacaine solution [3].

Ultrasound guidance allows reducing the dose of lidocaine for blockade of the sciatic nerve [4]. But the duration of lidocaine with adrenaline in a dilution of 1:200,000 is 2 - 2.5 hours [5]. Ropivacaine is used for a prolonged period of analgesia.

However, reducing the amount of ropivacaine may affect the duration of anesthesia the sciatic nerve. N. Moayeri *et al.* suggested that the ratio of the neural tissue and noneural affect the minimum effective dose of a local anesthetic. The authors noted that the rate of development of the sciatic nerve blockade depended on the amount of local anesthetic [6].

The purpose of this study is to determine the minimum volume and the amount of 0.75% ropivacaine solution for the blockade of the sciatic nerve, and the definition of the duration of regional anesthesia using small doses of ropivacaine.

2. Materials and Methods

Ethical approval for this study was acquired by the Ethical Committee of the Mogilev Regional Hospital, Belarus (President Dr. Alexandr R. Stolin), Protocol No. 30 on 5 September 2011.

Patients were randomized before the operation with respect to the manner of sciatic nerve block using one of two solutions, whose descriptions were randomly placed in sealed envelopes prior to the operation. We created two groups of patients, with 20 anesthesia performances in each group: A—block with 5 ml of 0.75% ropivacaine, B—block with 10 ml of 0.75% ropivacaine. The block was performed for patients before the operation on account of post-traumatic injuries and the dysfunction of shin bones, the genu joint, the talocrural joint, and foot, moving the metal constructions away from the shin bones.

The criteria for the inclusion of patients in the research included destination to an operation requiring anesthesia and the presence of the patient's written informed consent for the kind of anesthesia and its probable complications. The criteria for the exclusion of patients included the patient's refusal to take the proposed kind of anesthesia, patients who are too young (age < 18) or small (weight < 50 km), patients with a physical status value of ASA > 3, patients with allergic reactions to the applied medications in anamnesis, coagulopathy, infectious skin lesions at the injection area, neurological or nerve-muscular diseases, heavy liver diseases or kidney deficiency, and the inability to cooperate in the process. The characteristics of the groups are shown in **Table 1**.

All anesthetic solutions were prepared by the anesthesiologist, who did not take part in the research. The composition of the solutions was as follows:

Solution A: 5 ml ropivacaine HCl—0.75% (37.5 mg).

Solution B: 10 ml ropivacaine HCl—0.75% (75 mg).

With the aim of premedication, 0.5 - 0.8 mg of atropine and 10 mg of diphenhydramine were injected intramuscularly 20 - 30 min before the block. All patients received injections via venous access through catheter installation in a peripheral vein. SPO$_2$, electrocardiogram, and non-invasive arterial pressure were monitored. In order to sedate the patients, depending on their emotional state, 10 mg of Diazepam and/or 0.1 mg of Fentanyl was injected intravenously several minutes after the operation began.

Sciatic nerve block was performed using a posterior approach, with the patient lying on his/her belly, under ultrasonic control [5]. The Aloca SSC400 apparatus with an ultrasonic detector of 7.5 MHz was used for visualization. After getting a picture of the sciatic nerve, a 100 mm isolated injection needle (Stimuplex®, B. Braun Melsungen AG, Germany) connected to a neurostimulator (HNS 11, B Braun) was used to approach the nerve trunk until the appropriate group of muscles responded. The initial current strength was 0.4 mA (frequency 1 Hz, impulse length 100 μsec). After the muscular response and aspiration probe execution, a solution of local anesthetic was injected into the fascial sheath of the sciatic nerve [7] [8]. All blockades were performed under ultrasonic guidance, and in all cases we observed a "doughnut sign" effect. The method was completely blind as

Table 1. Characteristics of the studied patient groups.

Characteristics	Group	
	A n = 20	B n = 20
Age	42 (25; 46)	41 (37; 39)
Body weight, kg	80 (60; 85)	78 (70; 85)
Gender (M/F)	17/3	12/8

the anesthetist who performed the blockage did not see the syringe with the anesthetic. The syringe was in an assistant's hand behind a screen. The beginning of the solution injection was designated as zero point for the time control. In all cases for providing operations on extremities, an additional block of the femoral nerve using a "3-in-1" block was performed, depending on the region of the surgical operation [9]. The additional block was carried out in the same manner—with 25 ml of lidocaine 1% with the addition of epinephrine (1:200,000). The quality of the femoral nerve block or lumbar plexus branches (obturative nerve, lateral cutaneous nerve of hip, femoral nerve) block was assessed at once after 15 min.

The primary end point of the research was the point in time when complete sensory block was achieved. A cutaneous sensitivity assessment was carried out every 2 min until the 65th min of the block. The following scale was used for sensory block assessment: "++"—complete sensory block (anesthesia); "+"—incomplete sensory block, patient is not able to differentiate the type of irritant; and "−"—cutaneous sensitivity is fully preserved. Assessment of the patient's reaction was made using a pinprick test.

The secondary end points in this research were the complete motor block and the end of the analgetic effect of the blockade. Motor block assessment was carried out every 2 min until the 65th min after the local anesthetic injection, using the following scale: "++"—movements totally absent; "+"—movements preserved partly or not coordinated; "–"—movements fully preserved. Patients were asked to do a plantar flexion of the foot-tibial nerve and dorsiflexion with the common peroneal nerve. Both sensitivity and motor activity assessments were carried out by an independent anesthesiologist who did not take part in the research.

The duration of the postoperative analgesia was assessed through inquiry of the patient after surgery. Inquiry was done every 30 min by an independent anesthesiologist who did not take part in the research. The moment the patient started to complain about the sensation of pain in the operated region was noted as the end point of the regional block analgetic effect. Pain sensation was assessed according to the visual analogous scale (VAS), ranging from 0 mm (no pain) to 10 mm (intolerable pain). When pain sensation occurred in the region of the postoperative wound (1 - 2 points), 1 ml of 2% promedol was injected intramuscularly at 6 h intervals as an analgesia. We did not register the duration of the sensory and motor blocks.

Statistic processing of the data was carried out using Statistica 7.0 software. Three groups of patients were compared using the non-parametric method of a Kruskal-Wallis ANOVA. The zero hypothesis about the absence of differences was accepted at $p > 0.05$. If $p < 0.05$, the zero hypothesis was rejected, the differences between groups were accepted as statistically significant and a pairwise comparison of the groups was carried out using a non-parametric Mann-Whitney test. The data were figured as median and quartiles (25th and 75th percentiles).

3. Results

The research involved 40 patients. No differences existed between groups in terms of gender, body weight, age, or ASA classification. In all patients, the sciatic nerve was localized using ultrasonic pointing, and muscular response to electric stimulation was achieved. During anesthesia, the indices for SPO_2, electrocardiogram, and non-invasive arterial blood pressure did not decline from normal rates (the data are not provided here).

The complete sensory block (++) developed after 45 (40; 48) min in group A, after 30 (28; 30) min in group B. Reliable differences were observed among groups, $p < 0.05$ ($p = 0.000$).

The time for motor block development was 55 (50; 60) min in group A, 35 (34; 37) min in group B. We noted a reliable decrease in time as required for achieving the complete motor block of the sciatic nerve. The differences among the groups were reliable, $p < 0.05$ ($p = 0.000$).

Regional anesthesia duration in the postoperative period was 8 (7.5; 8) h for patients in group A, 8 (7; 8.5) h for patients in group B. No reliable differences in anesthesia duration occurred among the groups at p > 0.05 (p = 0.82) (**Table 2**).

4. Discussion

As stated by Taboada *et al*. [10], during sciatic nerve block using the subgluteal approach, the minimal volume for anesthesia development is 12 ± 3 ml of 1.5% mepivacaine. Latzke *et al*. [11] found that, for successfully blocking the sciatic nerve at the level of middle hip, the sufficient volume of the local anesthetic is less than 5 ml (1.5% mepivacaine). Our data showed that application of 5 ml of 0.75% ropivacaine in the gluteal area leads to a complete blockage of the sciatic nerve. Thus, we succeed to reduce the volume of 0.75% ropivacaine to 5 ml and reduce the amount to 37.5 mg while retaining the effective blockage of the sciatic nerve.

In our opinion, reducing the time required for the complete block development in group B compared to group A is associated with the application of twice as much ropivacaine in B as in A. The available literature data concerning this area of anesthesia is extensive. Previously published data obtained during the blockage of the humeral plexus by using the axillary approach showed that the rate of anesthesia development does not depend on the amount (mg) of local anesthetic [12] [13]. Slower development of motor and sensory block was noted by Riazi *et al*. [14], when 5 ml of ropivacaine was applied instead of 20 ml in the humeral plexus blockage. It should be noted that these data were obtained in the blockage of nerves with a small diameter. Taboada Muniz *et al*. [15] stated that the application of different volumes and concentrations of local anesthetic in sciatic nerve block according to Labat changes the time of anesthesia. As noted by Latzke *et al*. [11], the amount of anesthetic in sciatic nerve blockage has not yet been shown to have an effect on the time of sensory block development, but this aspect, as the author wrote, needs additional research.

According to Moayeri and Groen [6], the proportion of non-neural and neural tissue in the sciatic nerve is a factor influencing the rate of block development. In addition, the more non-neural tissue there is, the slower the anesthesia develops because the connective tissue is a barrier for local anesthetic diffusion. Considering that the diameter of the sciatic nerve is several times larger than that of the nerves of the humeral plexus in the axillary area, the amount of local anesthetic (mg) will likely influence the time of its diffusion through the sheath of nerves with larger diameters. According to Sala-Blanch *et al*. [16], during sciatic nerve block in the popliteal pit area by using the application of 20 ml of 1.5% mepivacaine, the anesthesia of the nerve developed after 15 min. The data collected by Taboada Muniz *et al*. [15] in terms of the influence of different volumes and concentrations of the time for block development, along with our application of ropivacaine (as an anesthetic agent with a subsequent effect), explain the longer time required for complete sensory and motor block development in groups A and B [sensory block: 45 (40; 48) and 30 (28; 30) min accordingly]. Thus, the available published data are discrepant and diverse. Our results are similar to the results described by Riazi *et al*. [14]. It is evident that the question about the effect of local anesthetic volume and amount of time required for peripheral nerve block development (in particular, the sciatic nerve) needs additional investigation.

Contradictory data about block duration depending on local anesthetic volume during the humeral plexus block were obtained by Ponrouch *et al*. [12] and Gauiter *et al*. [17]. As Ponrouch *et al*. noted, humeral plexus block duration decreases as the applied volume of 1.5% mepivacaine decreases (time of postoperative analgesia was not assessed) [12]. In the humeral plexus block using the interscalene approach, when 5 ml of 0.75% naropin was applied, block duration (9.9 [5 - 19] hours) and post-operation analgesia (9.9 ± 3.7 hours) did not change in comparison with blockades when performed using standard volumes (20 - 30 ml) of 0.75% ropivacaine [17]. In the sciatic nerve block, we obtained results similar to those of Gauiter *et al*. [17]. It is possible that

Table 2. The results of the blockade of the sciatic nerve in groups A and B.

Parameters of peripheral blockade of the sciatic nerve	Group	
	A (5 ml ropivacaine)	B (10 ml ropivacaine)
Time of onset of complete sensory blockade	45 (40; 48) min	30 (28; 30) min
Time of onset of complete motor blockade	55 (50; 60) min	35 (34; 37) min
The duration of analgesia	8 (7.5; 8)	8 (7; 8.5)

analgesia time duration does not depend on the amount of local anesthetic, if this amount is higher than the critical one. However, this question requires more detailed research.

A disadvantage is the small number of research groups of patients. When choosing the number of patients in the groups we considered the data of P. Cuvillon *et al.* which show that it is enough to have 20 people in the group to conduct such research [18]. We did not assess the amount of administered narcotic analgesics used after the analgesic effect of ropivacaine (after the onset of pain in the surgical wound).

5. Conclusion

In the literature, there are conflicting data on the duration of analgesia with a decrease in the dose of local anesthetic. This is the first study that evaluated the time of the siege and the duration of analgesia with a decrease in the dose of ropivacaine for sciatic nerve blockade with ultrasound guidance. Our data showed that sciatic nerve blockade with reduction of the effective dose of a local anesthetic duration of analgesia was not significantly changed. Reducing the dose of ropivacaine prolongs the latent period of the LA during the blockade of the sciatic nerve.

References

[1] Fanelli, G., Casati, A., Beccaria, P., Aldergheri, G., Berti, M., Tarantino, F., *et al.* (1998) A Double Blind Comparison of Ropivacaine, Bupivacaine, and Mepivacaine during Sciatic and Femoral Nerve Blockade. *Anesthesia & Analgesia*, **87**, 597-600.

[2] Neuburger, M. and Büttner, J. (2011) Complications of Peripheral Regional Anesthesia. *Anaesthesist*, **60**, 1014-1026. http://dx.doi.org/10.1007/s00101-011-1955-3

[3] Kuthiala, G. and Chaudhary, G. (2011) Ropivacaine: A Review of Its Pharmacology and Clinical Use. *Indian Journal of Anaesthesia*, **55**, 104-110. http://dx.doi.org/10.4103/0019-5049.79875

[4] Valery, P. and Aliaksei, M. (2014) Features and Principles the Spread of Local Anesthetic Blockade of the Sciatic Nerve at Depends on the Amount of Anesthetic. *Open Journal of Anesthesiology*, **4**, 31-35. http://dx.doi.org/10.4236/ojanes.2014.42004

[5] Chelly, J.E. (2009) Peripherial Nerve Blocks: A Color Atlas. 3rd Edition, Wolters Kluwer/Lippincott Williams & Wilkins, Philadelphia, 1-474.

[6] Moayeri, N. and Groen, G.J. (2009) Differences in Quantitative Architecture of Sciatic Nerve May Explain Differences in Potential Vulnerability to Nerve Injury, Onset Time, and Minimum Effective Anesthetic Volume. *Anesthesiology*, **111**, 1128-1134. http://dx.doi.org/10.1097/ALN.0b013e3181bbc72a

[7] Brull, R., Macfarlane, A.J., Parrington, S.J., Koshkin, A. and Chan, V.W. (2011) Is Circumferential Injection Advantageous for Ultra-Sound-Guided Popliteal Sciatic Nerve Block? A Proof-of-Concept Study. *Regional Anesthesia and Pain Medicine*, **36**, 266-270. http://dx.doi.org/10.1097/AAP.0b013e318217a6a1

[8] Perlas, A., Wong, P., Abdallah, F., Hazrati, L.N., Tse, C. and Chan, V. (2013) Ultrasound-Guided Popliteal Block through a Common Paraneural Sheath versus Conventional Injection: A Prospective, Randomized, Double-Blind Study. *Regional Anesthesia and Pain Medicine*, **38**, 218-225. http://dx.doi.org/10.1097/AAP.0b013e31828db12f

[9] Hadzic, A., Karaca, P.E., Hobeika, P., Unis, G., Dermksian, J., Yufa, M., *et al.* (2005) Peripheral Nerve Blocks Result in Superior Recovery Profile Compared with General Anesthesia in Outpatient Knee Arthroscopy. *Anesthesia & Analgesia*, **100**, 976-981. http://dx.doi.org/10.1213/01.ANE.0000150944.95158.B9

[10] Taboada, M., Rodriguez, J., Valino, C., Carceveller, J., Bascuas, B., Oliveira, J., *et al.* (2006) What Is the Minimum Effective Volume of Local Anaesthetic Required for Sciatic Nerve Blockade? A Prospective, Randomized Comparison between a Popliteal and a Subgluteal Approach. *Anesthesia & Analgesia*, **102**, 593-597. http://dx.doi.org/10.1213/01.ane.0000189188.08679.2a

[11] Latzke, D., Marhofer, P., Zeitlinger, M., Machata, A., Neumann, F., Lackner, E., *et al.* (2010) Minimal Local Anaesthetic Volumes for Sciatic Nerve Block: Evaluation of ED99 in Volunteers. *British Journal of Anaesthesia*, **104**, 239-244. http://dx.doi.org/10.1093/bja/aep368

[12] Ponrouch, M., Bouic, N., Bringuier, S., Biboulet, P., Choquet, O., Kassim, M., *et al.* (2010) Estimation and Pharmacodynamic Consequences of the Minimum Effective Anesthetic Volumes for Median and Ulnar Nerve Blocks: A Randomized, Double-Blind, Controlled Comparison between Ultrasound and Nerve Stimulation Guidance. *Anesthesia & Analgesia*, **111**, 1059-1064.

[13] Janzen, P.R., Vipond, A.J., Bush, D.J. and Hopkins, P.M. (2001) A Comparison of 1% Prilocaine with 0.5% Ropivacaine for Outpatient-Based Surgery under Axillary Brachial Plexus Block. *Anesthesia & Analgesia*, **93**, 187-191.

http://dx.doi.org/10.1097/00000539-200107000-00037

[14] Riazi, S., Carmichael, N., Awad, I., Holtby, R.M. and McCartney, C.J. (2008) Effect of Local Anaesthetic Volume (20 vs 5 ml) on the Efficacy and Respiratory Consequences of Ultrasound-Guided Interscalene Brachial Plexus Block. *British Journal of Anaesthesia*, **101**, 549-556. http://dx.doi.org/10.1093/bja/aen229

[15] Taboada Muniz, M., Rodriguez, J., Bermudez, M., Valino, C., Blanco, N., Amor, M., *et al*. (2008) Low Volume and High Concentration of Local Anaesthetic Is More Efficacious than High Volume and Low Concentration in Labat's Sciatic Nerve Block: A Prospective, Randomized Comparison. *Anesthesia & Analgesia*, **107**, 2085-2088. http://dx.doi.org/10.1213/ane.0b013e318186641d

[16] Sala-Blanch, X., de Riva, N., Carrera, A., López, A.M., Prats, A. and Hadzic, A. (2012) Ultrasound-Guided Popliteal Sciatic Block with a Single Injection at the Sciatic Division Results in Faster Block Onset than the Classical Nerve Stimulator Technique. *Anesthesia & Analgesia*, **114**, 1121-1127. http://dx.doi.org/10.1213/ANE.0b013e318248e1b3

[17] Gauiter, P., Vandepitte, C., Ramquet, C., DeCoopman, M., Xu, D. and Hadzic, A. (2011) The Minimum Effective Anesthetic Volume of 0.75% Ropivacaine in Ultrasound-Guided Interscalene Brachial Plexus Block. *Anesthesia & Analgesia*, **113**, 951-955.

[18] Cuvillon, P., Nouvellon, E., Ripart, J., Boyer, J.C., Dehour, L., Mahamat, A., L'Hermite, J., Boisson, C., Vialles, N., Lefrant, J.Y. and de La Coussaye, J.E. (2009) A Comparison of the Pharmacodynamics and Pharmacokinetics of Bupivacaine, Ropivacaine (with Epinephrine) and Their Equal Volume Mixtures with Lidocaine Used for Femoral and Sciatic Nerve Blocks: A Double-Blind Randomized Study. *Anesthesia & Analgesia*, **108**, 641-649. http://dx.doi.org/10.1213/ane.0b013e31819237f8

Scientific Research Publishing (SCIRP) is one of the largest Open Access journal publishers. It is currently publishing more than 200 open access, online, peer-reviewed journals covering a wide range of academic disciplines. SCIRP serves the worldwide academic communities and contributes to the progress and application of science with its publication.

Other selected journals from SCIRP are listed as below. Submit your manuscript to us via either submit@scirp.org or Online Submission Portal.