ANATOMICAL AND ULTRASOUND STUDY OF THE MID-FEMORAL SCIATIC NERVE AND ITS DIVISION

VRZGULA MARKO[1], HUDAK VLADIMIR[2], LOVASOVA KVETUSE[1], VECANOVA JANKA[1], HVIZDOSOVA NATALIA[1], MIHALIK JOZEF[1], HODOROVA INGRID[1]

[1] Department of Anatomy, Faculty of Medicine, Pavol Jozef Šafárik University in Košice, Slovak Republic
[2] First Department of Anaesthesiology and Intensive Medicine, Faculty of Medicine, Pavol Jozef Šafárik University in Košice, Slovak Republic

Abstract

OBJECTIVES: Anatomical variations of the sciatic nerve were supposed as potential causes for incomplete blocks at the level of the popliteal fossa. Therefore, we aimed to conduct an anatomical and ultrasound survey of the mid-femoral sciatic nerve and its division.
BACKGROUND: A regional block of the sciatic nerve is a procedure for analgesia and anaesthesia of the lower extremity. Various approaches to the sciatic nerve are used in clinical practice. However, the sciatic nerve demonstrates several variations regarding its topography and division.
MATERIALS AND METHODS: The anatomical study included twenty lower limbs of ten adult cadavers. The ultrasound study involved ten upper legs of five healthy volunteers
RESULTS: The sciatic nerve was found distally to the piriformis muscle in all our cadaveric specimens. It was divided into two major branches (common peroneal nerve and tibial nerve) at a mean distance of 68.1 ± 19.3 mm above the popliteal crease. The observed distances ranged widely from 35 to 113 mm. The mid-femoral sciatic nerve and its division were entirely revealed using ultrasound in all volunteers.
CONCLUSION: The sciatic nerve presents significant anatomical variations, which may cause an incomplete block. Understanding ultrasound anatomy and ultrasound appearance of the sciatic nerve is essential for performing ultrasound-guided sciatic blocks.

Keywords: anatomy; dissection; nerve block; sciatic nerve; ultrasonography

INTRODUCTION

Regional blockade of the sciatic nerve (SN) is a commonly used method for providing analgesia and anaesthesia to the lower extremity and there are several different approaches to SN. The rate of success for all procedures is generally 90–95%, with about 5 % of cases necessitating additional general anaesthesia. An incomplete block is thought to be the outcome of defective diffusion (due to SN size), unconnected epineural fascial coverings of the common peroneal nerve (CPN) and tibial nerve (TN), or a block of a single SN component. SN block is frequently performed in the popliteal fossa (PF) at the area of the bifurcation of the SN. The applications of local anaesthetics close to the division of SN have the advantage of being relatively superficial and allowing the anaesthetics to be distributed to CPN and TN. The name of this procedure is popliteal block. A popliteal block anaesthetizes the whole leg distally to the proximal epiphysis of the tibia except for the medial surface of the foot and calf. The needle tip must be ideally positioned close to the SN main trunk. If the local anaesthetic is applied too distal, the probability of an incomplete block increases because the two main branches of the SN have separated (1–4).

Corresponding author: Marko Vrzgula, MD; e-mail: marko.vrzgula@upjs.sk

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Anatomy

SN is a mixed nerve, the largest in the human body. Motor fibres innervate the dorsal group of the muscles of the thigh, including semimembranosus, semitendinosus, and biceps femoris. They also supply the ischial part of the adductor magnus and all muscles below the knee (5). Sensory fibres of the SN innervate the skin of the foot and lower leg, except for the supply of the medial region of the calf and the medial margin of the foot, which is provided by the saphenous nerve (6). SN comes from the sacral plexus and consists of ventral branches of the fourth lumbar to a third sacral spinal nerve. The ventral branches of these spinal nerves are positioned on the piriformis muscle's anterior surface. SN exited the pelvis via the greater sciatic foramen, generally under the piriformis. It then continues along the thigh's posterior surface medially to the greater trochanter and laterally to the ischial tuberosity (7). Two nerves of the sacral plexus, CPN and TN, form together SN. They are bound together initially by connective tissue; TN lies anteriorly and medially, and the CPN is located more laterally and posteriorly. Within the SN, both components are surrounded by their own epineural sheaths and separated from each other by a thin Compton – Cruveilhier septum. The SN is situated on the posterior surface of the adductor magnus, deep to the biceps femoris, when it penetrates the thigh and descends to the PF. In the upper edge of the PF, the SN is bordered medially by the tendons of semimembranosus and semitendinosus and laterally by the tendon of the long head of the biceps femoris. SN is located lateral and posterior to the popliteal artery and popliteal vein in the upper part of the PF. It usually splits itself into its component nerves, CPN and TN, within the apex of the PF (1,8,9). The TN runs parallel to the popliteal vessels and straight caudally, deep inside the PF. Following its separation superficially and laterally, the CPN continues parallel to the biceps femoris distal tendon (10).

MATERIALS AND METHODS

Both studies were realized at the Faculty of Medicine of Pavol Jozef Šafárik University in Košice. An anatomical survey was conducted on twenty lower limbs of ten adult cadavers during undergraduate dissections for first-year general medicine students. All cadavers were under the administration of the Department of Anatomy and were acquired from the body donation program after signing the informed consent of the donors themselves. Of these, five were males and five were females. All cadavers were without the finding of obvious pathology and were preserved with a formalin-based solution soon after death. For the purpose of our research, the popliteal crease (PC) was found, the skin with the subcutaneous tissue at the level of PF was taken off, and further dissection was performed to identify CPN and TN. Next, a posterior thigh dissection was performed to discover the position of the SN, and a location of bifurcation was noticed. The division of the SN was defined as the point where the epineural sheath of the SN was divided into the separate epineural sheaths of its terminal branches. Finally, a dissection of the gluteal region was also fulfilled and the nerve's exit from the pelvis and its relation to piriformis was recorded. For each dissected lower extremity, the distance between the bifurcation of the SN and PC was measured. Metric analyses were performed using a sliding calliper and the possible error was estimated at 0.5 mm. A paired t-test was run to compare the distances from the SN division to the PC between the sides of the lower limbs (right vs left) and between sexes (male vs female). Statistical significance was determined by p-values less than 0.05.

An ultrasound survey of the SN location was carried out using an ultrasound unit LOGIQ V2, GE Healthcare Systems, United States, at the First Department of Anaesthesiology and Intensive Medicine. After written informed consent, five healthy adult volunteers (2 males, 3 females, 33–55 years old, 55–90 kg, 162–185 cm) participated in this study. The volunteers were staff members of the same department. The exclusion criteria were upper leg skin inflammation, lower limb pain, and immobility. Ultrasound scans were performed from

the dorsal approach in a prone position using a linear transducer array with the frequencies of 8 to 13 MHz by a radiologist and an anaesthesiologist with 10 and 25 years of experience, respectively. In all volunteers, two thighs were examined and the SN was systematically scanned in the cross-section from the midthigh to the PF.

RESULTS

The results of the anatomical study are presented using mean and standard deviation.

Ten right and ten left thighs from five male and five female cadavers were examined. The SN, CPN, and TN were identified in all dissected lower extremities (Fig. 1). The SN exited the pelvis below the piriformis in all our specimens (type A in the Beaton and Anson classification system). It was divided at a mean distance of 68.1 ± 19.3 mm above the PC. The measured distances ranged from 35 to 113 mm (Fig. 2). There was no statistical difference in the measured distances by sides in all cadaver legs (69.8 ± 17.9 mm vs 66.4 ± 22.4 mm for right and left sides, respectively; p=0.712). In addition, the measured distances did not differ between the sexes (69.4 ± 24.7 mm vs 70.2 ± 10.5 mm for right male and female lower limbs, respectively; p=0.948 and 64.4 ± 17.6 mm vs 68.4 ± 28.3 mm for left male and female lower limbs, respectively, p=0.795).

The SN was clearly seen by ultrasound as a round to oval hyperechoic formation with a fascicular structure. In the mid femoral region, that is in the second third of the distance from the greater trochanter to the PC, SN was located dorsally from the adductor magnus and ventrally from the long head of biceps femoris (Fig. 3). The popliteal part of the SN was found superficially and laterally to the main vessels in the PF. The most medial and most deep-seated was the popliteal artery. Over it was the popliteal vein, and most superficially was positioned the SN. It was divided here into the CPN (lateral) and TN (medial) (Fig. 4). In all volunteers, the SN division and proximal parts of the CPN and TN were entirely revealed using ultrasound. The internal appearance of the nerves in short-axis visualization was seen as honeycomb hypoechoic areas surrounded by hyperechoic structures. The hypoechoic portions represent nerve tissue, whereas the hyperechoic regions correspond to fibrous and adipose tissue.

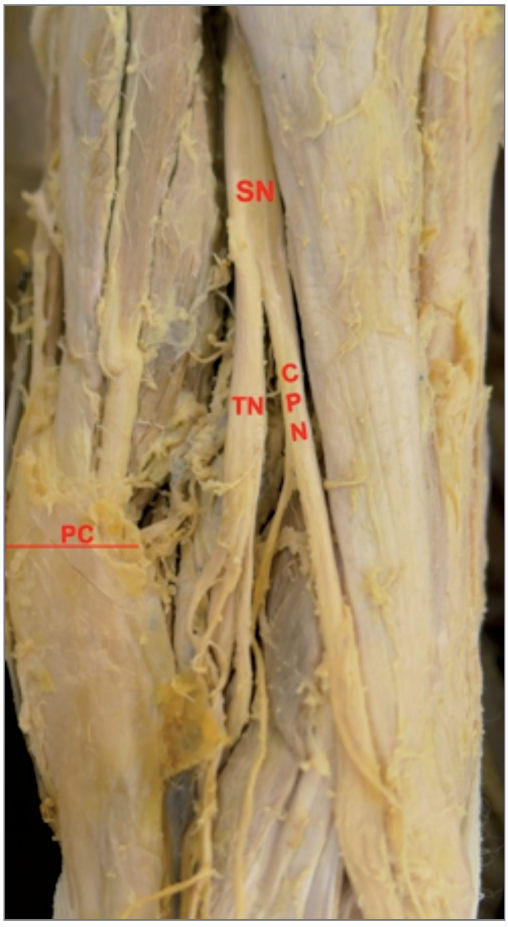


Fig. 1 Division of the sciatic nerve, right side, posterior view. PC – level of the popliteal crease, SN – Sciatic nerve, TN – Tibial nerve, CPN - Common peroneal nerve

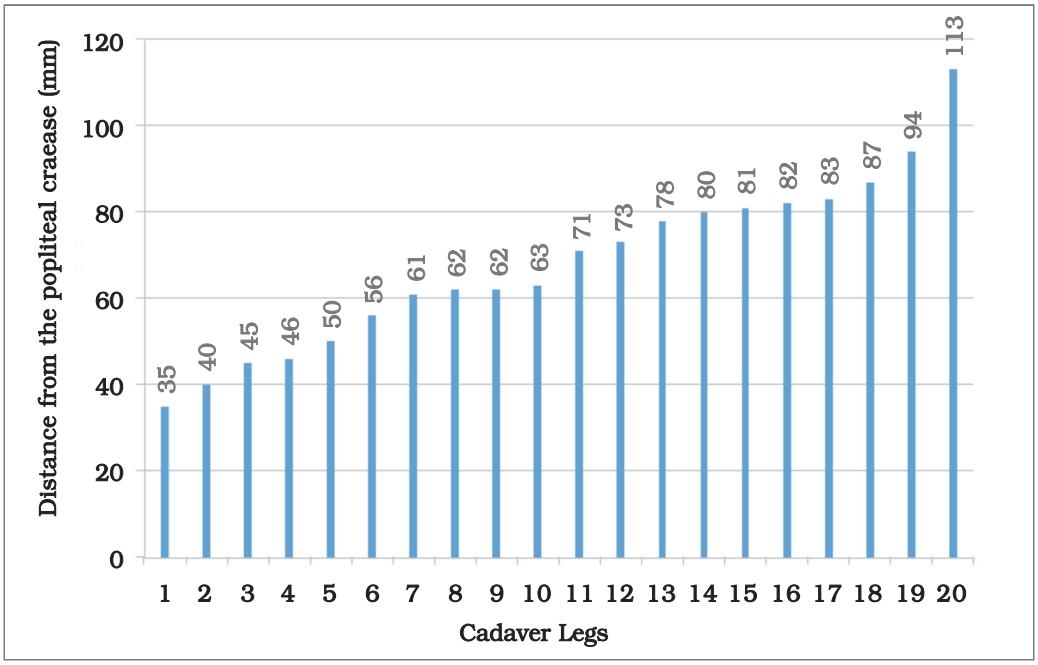


Fig. 2 Division of the sciatic nerve into its component nerves above the popliteal crease.

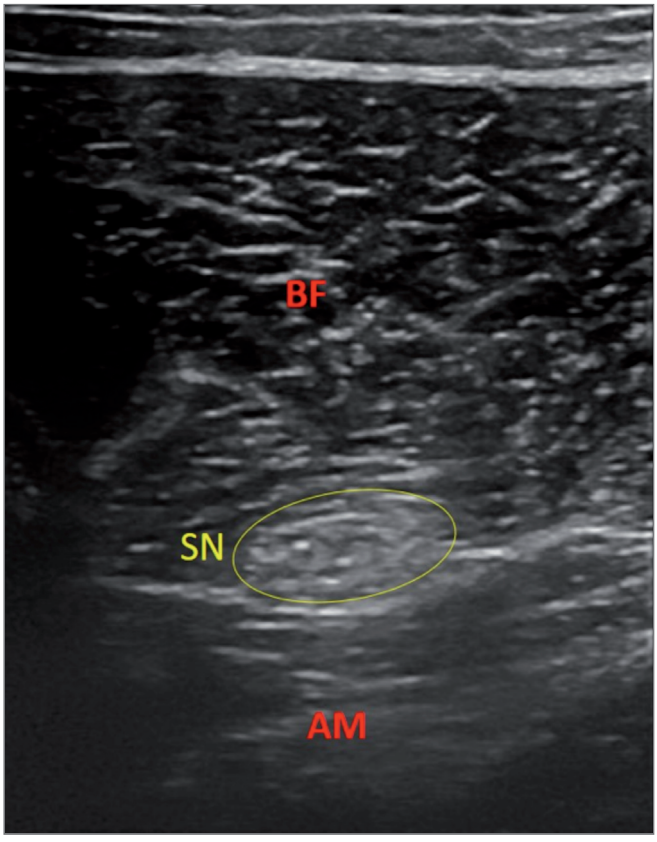


Fig. 3 The mid-femoral sciatic nerve, right side, prone position. BF – Biceps femoris, AM – Adductor magnus, SN – Sciatic nerve

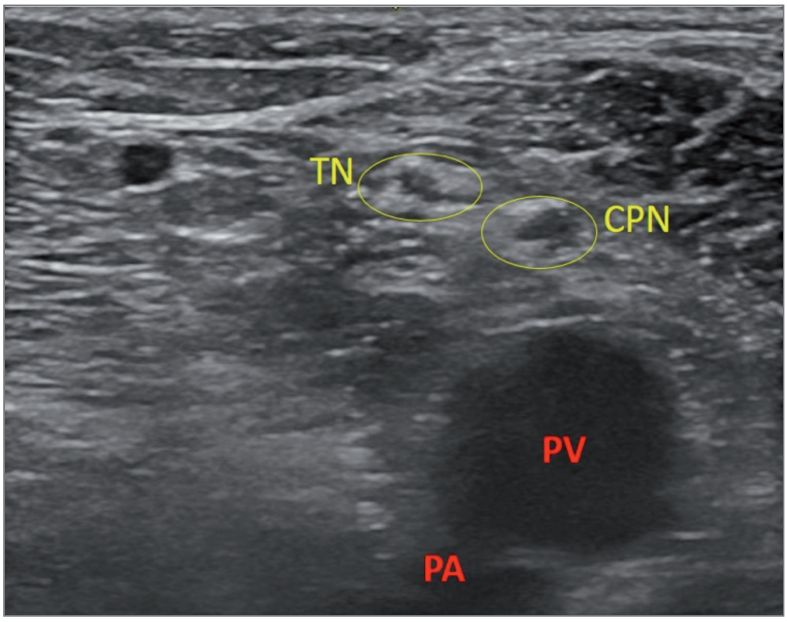


Fig. 4 Division of the sciatic nerve, right side, prone position. TN – Tibial nerve, CPN – Common peroneal nerve, PV – Popliteal vein, PA – Popliteal artery

DISCUSSION

In clinical practice, several techniques for the SN block are used. The majority of methods that have been reported to this date rely on complex superficial anatomical landmarks. Surface anatomical landmarks offer helpful guides for determining the position of the SN, but sometimes these may be difficult to locate. They can differ across patients and their exact localization may be challenging, especially in obese patients. Additionally, it is essential to note that a motor response may not always be elicited by electrical nerve stimulation and success is not always guaranteed (11).

Some authors have reported variants of SN bifurcation into the CPN and TN between the pelvis and PF (12–15). SN anatomy's variations are indispensable to remember, mainly during SN blocks and hip surgery. A higher bifurcation of the SN, where it can split into its terminal branches anywhere in the pelvis or thigh, is a somewhat common occurrence. In the case of the pelvis, the whole nerve or its terminal branches may emerge through the piriformis muscle, above it, or below it (16).

Six anatomic SN variants are described in the classification system of Beaton and Anson. Most often, the undivided SN runs distally to the piriformis muscle (type A). The TN runs inferiorly to the piriformis in type B, while the CPN penetrates the piriformis. The CPN runs in type C superiorly to the piriformis and the TN below piriformis. The undivided SN penetrates the piriformis in type D. The TN penetrates the piriformis, whereas the CPN runs above it in type E. Finally, the undivided SN runs superiorly to the piriformis muscle in type F (17, 18). In addition, some muscle variations in the popliteal region were also described (19, 20). It is requisite to be familiar with the possibility that they may cause difficulty in needle insertion.

Our data from the anatomical study show that the SN splits itself into its two components, CPN and TN, at varied distances from the PC. Variants of the SN may result in an incomplete block because of the local application of anaesthetic close to only one of these components (4). In the realized ultrasound survey, the SN and its division were consistently and reliably identified in all volunteers. The ultrasound image was made optimal after the probe's slow cranially and caudally movement in the posterior mid-femoral region while

preserving the cross-section view until the SN was recognized. Peripheral nerve ultrasound imaging depends on the nerve's shape, spatial orientation, internal architecture, and capability of recognizing nearby structures (10). Our study indicates that the mid-femoral SN and its division can be easily visualized using ultrasound. Ultrasound imaging increases the possibility of achieving a close placement of the tip of the needle to the SN by a successful localization of its division.

CONCLUSION

One of the methods for a lower limb regional anaesthesia is the SN block. SN can be found at various levels from the gluteal region to the PF. It can be reached along the sciatic line which starts from the apex of the PF and ends in the middle of the axis between the ischial tuberosity and the greater trochanter (21). However, anatomical variations of the SN may be the cause of the incomplete block.

In conclusion, our anatomical study's results display the different positions of SN division. In addition, we also describe the ultrasound anatomy and ultrasound appearance of the SN and its major branches.

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Ethical approval

Informed consent has been regularly acquired from each and every volunteer included in the manuscript. All cadavers were acquired from the body donation program after signing the informed consent of the donors themselves. No ethical clearance was required as cadavers are used for teaching and research purpose.

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