SONOGRAPHIC EVALUATION OF SCIATIC NERVE ANATOMY AND SUBCUTANEOUS DEPTH AT ITS TERMINATION IN POSTERIOR THIGH: IMPORTANCE IN POPLITEAL BLOCKS

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ABSTRACT

Introduction: Sciatic nerve (SN) is about 2cm wide, forms in the pelvis from ventral rami of L4-S3 spinal nerves and leaves the pelvis by passing out via greater sciatic foramen inferior to piriformis. It travels in the posterior compartment of thigh where it is crossed by long head of biceps femoris, and terminates by dividing into tibial and common peroneal nerves proximal to knee near the apex of popliteal fossa. Cross sectional area (CSA) of SN at mid-thigh and the level of termination may vary. This is important in respect to clinical as well as treatment purpose for the performance of popliteal block. Popliteal nerve block is the block of SN in the popliteal fossa, it is ideal for surgeries of lower leg, particularly below the knee, foot and ankle. It anesthetizes the same dermatomes as both the anterior and lateral approaches to the SN. Variability in level of termination and subcutaneous depth may account for the frequent failures associated with popliteal block. Ultrasound guided sciatic nerve blockade when performed in a systematic manner, is associated with a high success rate.

Aims & Objectives: Present study was done to evaluate sciatic nerve morphometry and its depth from skin with the help of high resolution ultrasonography (HRUS) and highlight importance of relevant anatomy in relation to popliteal nerve block.

Material & Methods: Study was conducted in the Department of Anatomy, King George's Medical University, Lucknow, Uttar Pradesh, India in 50 volunteer students of 1st year MBBS 2018 batch (25 males & 25 females). Sonography was done with the help of Esaote Europe My Lab 40 ultrasound machine (installed in the Department of Anatomy, KGMU) to observe Cross sectional area, perimeter, level of termination of nerve and its depth from skin at a particular site.

Results: CSA ranged from $0.22-0.35 \pm 0.028 \text{ cm}^2$ and perimeter ranged from $15.23 - 30.33 \pm 2.92 \text{ mm}$. The mean CSA of SN was equal on both sides i.e. $0.27 \pm 0.028 \text{ cm}^2$ on right and $0.27 \pm 0.025 \text{ cm}^2$ on left. The perimeter of SN on right side was $21.27 \pm 2.92 \text{ mm}$ and left side $20.29 \pm 2.05 \text{ mm}$. The depth of SN from skin on right side was $19.16 \pm 1.70 \text{ mm}$ while on left side $19.16 \pm 1.70 \text{ mm}$. The level of termination was $77.65 \pm 4.31 \text{ mm}$ on right side while $77.26 \pm 4.43 \text{ mm}$ on left side proximal to popliteal crease.

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Rt. SN mean CSA was almost equal among males and females whereas Lt. SN mean CSA was found to be significantly (p-value-0.048) greater in males as compared to females.

The perimeter of nerve had significantly (0.043) larger values on both right and left side in females as compared to males. The depth of SN from skin was slightly more in males as compared to females while level of termination was bilaterally almost similar in both males and females.

Conclusion: Normal values of various parameters of sciatic nerve evaluated in our study will be helpful in guiding and facilitating popliteal block in various surgeries.

Keywords: Ultrasonography, sciatic nerve, popliteal nerve block

INTRODUCTION

Sciatic nerve (SN) is a branch of lumbo-sacral plexus, it is the thickest nerve in the body and is about 2cm wide [1]. It originates from the ventral rami of L4-S3 roots in the form of two nerve trunks the tibial nerve (TN) and the common peroneal nerve (CPN) that course within a single epineural sheath. Its course corresponds to a line drawn from just medial to the midpoint between the ischial tuberosity and greater trochanter to the apex of the popliteal fossa (at the junction of middle and lower third of the thigh where the TN and CPN finally separate [2]. In the popliteal fossa, sciatic nerve is bordered superolaterally by long head of biceps femoris and superomedially by semimembranosus (SMM) and semitendinosus (STM) muscles.

Measurement of cross-sectional area (CSA) of the nerve is the most widely accepted and reliable method for the diagnosis of nerve disorders. Thus, determination of reference value of CSA is crucial to identification of nerve pathology and proper diagnosis [3-6]. The studies have shown that the level of bifurcation of SN can be above or below the normally described level [7-9]. The knowledge of level of termination is important from clinical as well as treatment purpose. Sciatic nerve block is given in the popliteal fossa and is ideal for surgeries of lower leg, particularly below the knee, foot and ankle [10,11]. It anesthetizes the same dermatomes as both the anterior and lateral approaches to the SN [12-15]. It preserves the hamstring function and allows easier ambulation of post-operative patients. The insertion of the needle at 100 mm above the popliteal crease ensures placement of the needle in the vicinity of or proximal to the division of the SN [16]. The SN divided at a mean distance of 60.5 ± 27.0 mm (range 0 to 115 mm) above the popliteal fossa crease [16]. Previously frequent failures of popliteal nerve block were noted during blind procedures due to variable levels of termination. Ultrasound guided Sciatic nerve blockade can be done at different levels along the posterior aspect of thigh via gluteal, subgluteal and popliteal approach. It is routinely done for surgery and pain management of lower extremity and is a commonly used technique in clinical practice. When performed in a systematic manner, it is associated with a high success rate [17,18].

High resolution ultrasonography (HRUS) has become a preferred technique for peripheral nerve imaging, it allows visualization of nerve caliber, continuity, echogenicity, echotexture, and is also able to identify tumours, traumatic lesions, entrapments with nerve damage, inflammation, demyelinating features or infections. Nerve blocks, biopsies or therapeutic application of drugs like procedures can be easily done by ultrasound guided interventions. Popliteal fossa is a preferred site for catheter insertion for post-operative analgesia. For the surgery on foot and ankle popliteal block is preferred over the gluteal and subgluteal approach as there is no hamstring weakness with this block. Anatomical variations of sciatic nerve termination have been suspected as a possible cause for incomplete block of the SN in the popliteal fossa [19-21]. We conducted a sonographic study to observe the morphometry (CSA and perimeter), level of termination and depth of SN from the skin, to create a nomogram that will help in avoiding the pitfalls in the diagnosis of nerve pathologies as well as help the anaesthesiologists in giving sciatic nerve block.

The aim of the study was anatomical evaluation of right and left sciatic nerves in posterior thigh and to observe its depth from skin by ultrasonography. Parameters of sciatic nerve observed in the distal thigh included cross-sectional area (CSA), perimeter, level of termination (LOT) and depth from skin (DFS).

MATERIAL AND METHODS

The study included 50 volunteers from 1st year MBBS 2018 batch (25 male & 25 female students). Ultrasonography was done using Esaote Europe My Lab 40 ultrasound machine (installed in the Department of Anatomy, King George's Medical University, UP) with linear probe of frequency 6-13 MHz. Subjects were made to lie in a prone position with leg extended and a pillow was placed under the ankle to support the leg. The popliteal crease was identified and a line was marked proximal to popliteal crease. Skin and transducer preparation was done and the sciatic nerve was identified at this level and traced distally upto the level of termination (Fig. 1).

The nerve was identified on the basis of characteristic echopattern, described as, "honeycomb shaped" because of dark punctuate areas (fascicle groups) surrounded by hyperechoic band (perineurium). In the longitudinal plane, it was seen as a long, slim structure with parallel hypoechoic and hyperechoic lines [22].

The cross sectional area, perimeter, depth from skin were assessed at the level of termination and distance of the sciatic nerve termination to the popliteal fossa crease was measured and recorded. At each site where depth of nerve from skin surface was measured by tracing the hyperechoic rim, care was taken to ensure that the transducer was perpendicular to nerve (Fig. 2). All the readings were recorded by single observer carefully and were compared on the left and right side.

Fig. 1: Showing position of sonographic linear probe at termination of sciatic nerve proximal to popliteal crease

Fig. 2: Showing left sciatic nerve anatomy proximal to the popliteal crease

OBSERVATIONS AND RESULTS

Sonographic measurements from 50 subjects (25 males and 25 females) were evaluated and the results were recorded. Overall CSA of Sciatic nerve ranged from 0.22 - 0.35 cm² and overall perimeter ranged from 15.25 – 30.25 mm. The mean CSA of Rt. SN was 0.27± 0.028 cm² and Lt. SN was 0.27±0.025 cm². The mean CSA was equal on both right and left sides (Rt=Lt). Rt. SN mean CSA was almost equal among males (0.27± 0.019 cm²) and females (0.27± 0.035 cm²) whereas Lt. SN mean CSA was found to be significantly (p-value-0.048) greater in males (0.28± 0.162 cm²) as compared to females (0.27± 0.025 cm²). The perimeter of Rt. SN was 21.27±2.92 mm and Lt SN was 20.29±2.05 mm. The perimeter of SN in females had significantly larger values (p value-0.043) on both sides (Rt SN-21.67±3.78mm; Lt SN-20.88±2.22mm) as compared to males (Rt SN-20.88±1.67mm and Lt SN 19.70±1.72mm) (Table 1).

Table 1: Mean cross-sectional area (cm²) and perimeter (mm) of sciatic nerve just proximal to its termination (Right and Left lower limbs=100)

Group		Rt. SN		Lt. SN	
		CSA(cm ²)	Perimeter(mm)	CSA(cm ²)	Perimeter(mm)
Males (25)	Min.	0.24	18.32	0.26	16.25
	Max.	0.32	25.06	0.33	23.7
	Mean	0.27	20.88	0.28	19.70
	SD	0.019	1.67	0.162	1.72
Females (25)	Min.	0.22	15.25	0.22	18.19
	Max.	0.35	30.25	0.33	27.22
	Mean	0.27	21.67	0.27	20.88
	SD	0.035	3.78	0.025	2.22
Total(50)	Min.	0.22	15.25	0.22	16.25
	Max.	0.35	30.25	0.33	27.22
	Mean	0.27	21.27	0.27	20.29
	SD	0.028	2.92	0.025	2.05

(CSA-cross sectional area, Rt. SN-right sciatic nerve, Lt. SN-left sciatic nerve)

Level of termination in respect to popliteal crease ranged from 70.1- 88.6 mm and depth under the skin ranged from 15.30–23.50 mm. Level of termination of Rt. SN was 77.48 ± 4.26 mm proximal to popliteal crease in males whereas it terminated 77.81 ± 4.44 mm proximal to popliteal crease in females. Left sciatic nerve terminated at a distance of 77.18 ± 4.41 mm and 77.03 ± 4.53 mm from popliteal crease in males and females respectively. The level of termination of SN on right side was 77.65 ± 4.31 mm was insignificant and slightly more proximal as compared to Lt. SN 77.26 ± 4.43 mm.

Average depth of right sciatic nerve was 19.71 ± 1.21 mm in males and 19.18 ± 1.41 mm in females ($M \geq F$) whereas left sciatic nerve was 19.61 ± 1.80 mm deep in males and 18.71 ± 1.50 mm in females ($M > F$). The depth of SN from skin on right side was 19.16 ± 1.70 mm while on left side 19.16 ± 1.70 mm ($Rt = Lt$). The depth of SN from skin was slightly more in males as compared to females while level of termination of SN almost equal in both male and females (Table 2, Fig. 3).

Table 2: Level of termination and depth from skin at its termination (Right and Left lower limbs=100)

Group		Rt. SN		Lt. SN	
		LOT(mm)	DFS(mm)	LOT(mm)	DFS(mm)
Males (25)	Min.	70.5	18.2	70.8	15.5
	Max.	88.6	22.5	88.5	23.5
	Mean	77.48	19.71	77.18	19.61
	SD	4.26	1.21	4.41	1.80
Females (25)	Min.	70.1	16.7	70.2	15.3
	Max.	87.6	23.8	88.5	21.5
	Mean	77.81	19.18	77.03	18.71
	SD	4.44	1.41	4.53	1.50
Total(50)	Min.	70.1	15.3	70.2	15.3
	Max.	88.6	23.5	88.5	23.5
	Mean	77.65	19.16	77.26	19.16
	SD	4.31	1.70	4.43	1.70

(SN-Sciatic Nerve, LOT-Level of termination of sciatic nerve, DFS-Depth of nerve from skin)

Fig. 3: Bar diagram showing Genderwise comparison of CSA, Perimeter, DFS and LOT of sciatic nerve

DISCUSSION

Ultrasonographic findings of sciatic nerves revealed mean CSA ranging from 0.22 - 0.35 cm² which was similar to values reported by Cartwright et al. (2008) [3], Lo et al. (2007) [23], Tagliafico et al. (2012) [24], Seok et al. (2014) [5] and Kim et al. (2016) [25], but less than the findings reported by Latzke et al. (2009) [26] and Jun Chen et al. (2018) [27]. In present study, CSA did not differ by laterality and we found no significant side-to-side differences between right and left side nerves which was similar to study done by Tagliafico et al. (2012) [24]. In present study, females had smaller CSAs of the normal sciatic nerves than men which was similar to the observation of Jun Chen et al. (2018) [27].

Perimeter of sciatic nerve in our study ranged between 15.23 – 30.33 mm. The mean perimeter was greater on right side in comparison to left. The perimeter of SN was found to be significantly larger in females in comparison to males. The perimeter observed in the present study was less than that reported by Latzke et al. (2009) [26], as they didn't mentioned any correlation of laterality and gender with perimeter in their studies.

The overall mean level of termination of sciatic nerve ranged from 70.1- 88.6 mm; it was similar to the findings observed by Singelyn et al. (1991) [28], Volka et al. (2001) [16] and Silverman et al. (2017) [29]. Level of termination reported in our study was greater than the findings reported by Sinha et al. (2014) [8]. In present study, mean of level of termination of sciatic nerve on right side was found to be slightly, but insignificantly, more proximal to popliteal crease than on left side. According to the previous studies, distances did not differ by laterality as reported by Singelyn et al., (1991) [28] and Volka et al. (2001) [16]. In present study overall level of termination was equal in both males and females, no gender based difference in the level of termination was also reported by Volka et al. (2001) [16] and Singelyn et al. (1991) [28].

Mean depth of sciatic nerve from skin ranged from 15.30–23.50 mm. Our range of subcutaneous depth is less as compared to findings observed by Osaka et al. (2011) [30], who found the distance of nerve from skin was 3.0–5.5 cm, also Munirama et al. (2013) [31] who found it to be 4.0 cm and Tedesco et al. (2019) [32] who reported it as 4-6 cm deep from skin. Vincent et al. (2006) [33] observed 15 subjects and code the mean of sciatic nerve depth from skin was 3.48 ± 0.91 cm. Latzke et al. (2009) [26] conducted his study on 20 subjects and noted the mean reference value 28.3 (17.2-37.1mm) which coincides with present study.

In present study, we found that the values of CSA and perimeter obtained from HRUS of both right and left limb showed similarity. Hence either of the nerves at this site could be used as control while comparing from the other side for any evaluation as a part of diagnosis or follow up. The overall level of termination was equal in both males and females. Depth of nerve from skin was bilaterally less in females than males in both sides.

The clinical importance of peripheral regional anaesthesia is rapidly growing. Today, peripheral nerve blocks managed a large spectrum of surgical and pain-related cases. Success rates and safety measures in daily clinical practices are the most important prerequisites for the use of peripheral regional anaesthesia. These are closely related to the administered volumes of local anaesthetics. Direct ultrasonographic visualization of nerve structures enables the performance of blocks with reduced volumes of local anaesthetics [34]. In an early attempt, our study group showed that the ultrasound guided measurement of various parameters of nerves may be useful in nerve block for different surgical procedures.

CONCLUSION

Knowledge of anatomical variations of the SN is of importance in orthopedics, anaesthesia and surgery. Variant anatomy of the sciatic nerve may influence the posterior hip operation. High division may develop in sciatica, resulting in nerve injury during deep intramuscular injections in gluteal region, piriformis syndrome, failed SN block in anesthesia and injury. Interpretation of sciatic neuropathy can be complicated by variation in division of SN. The knowledge of variations in the course and level of division

of SN serves anesthetist during popliteal sciatic block to improve clinical results. Hence, nerve imaging and extra operative alertness are suggested during different surgical procedures of the popliteal regions.

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