ROLE OF HIGH-RESOLUTION ULTRASOUND IN ASSESSMENT OF IATROGENIC SCIATIC NERVE INJURY IN PEDIATRIC AGE GROUP IN CORRELATION WITH ELECTROPHYSIOLOGICAL STUDIES

Mary Samir Samuel Abadir[1], Hanan Mahmoud Hussein Arafa[1], Soad Said Ahmed El Molla[2] and Noha Mohamed Gamal El Deen[1]

[1]Department of Radiodiagnosis, Faculty of Medicine, Ain Shams University, Cairo, Egypt.
[2]Department of Rheumatology, Physical Medicine & Rehabilitation, National Institute of Neuro-Motor System, Giza, Egypt.

Corresponding author:
Mary Samir Samuel
Mobile: +2 01225454071
E-mail:
marysamir025@gmail.com

Received: 13/02/2024
Accepted: 09/03/2024

Online ISSN: 2735-3540

ABSTRACT:

Background: *The sciatic nerve is among the largest peripheral nerves in terms of thickness within the body. Injecting the gluteal muscles can lead to an iatrogenic issue known as sciatic nerve injury, which can result in notable health complications. It may lead to different symptoms from mild paresthesia to serious neurologic sequel.*

Aim of the work: *To clarify the role of ultrasound (US) in the assessment of the sciatic nerve injury in correlation of electrophysiological studies.*

Material and methods: *This study was performed prospectively including 40 children complaining of unilateral limping or paresthesia of lower limbs with history of intramuscular injection in the buttocks. These patients were examined by ultrasound (US) and Nerve conduction studies (NCS) for their lower limbs. All US covered the whole length of sciatic nerve and muscles from the popliteal fossa up to the greater sciatic notch. The nerve was examined as regards the contour, architecture (fascicular pattern), caliber and integrity of the injured sciatic nerve segment as well as the measurement of cross-sectional area (CSA) in maximum diameter. On the other hand, the muscles (peroneus muscles, calf muscles and posterior thigh muscles) were examined as regards fatty infiltration and decreased circumference. NCS were performed for tibial and common peroneal nerves. All concerned studies were recorded for the affected limb and compared to the contralateral normal limb.*

Results: *US confirmed the clinical diagnosis of sciatic nerve injury in all included patients; while, NCS confirmed the clinical diagnosis of sciatic nerve injury in only 71% of the included patients. There was no correlation between the electrophysiological findings and dynamic US findings.*

Conclusion: *US can be utilized as the initial imaging of choice for the evaluation of iatrogenic sciatic nerve injury especially in acute phase when nerve conduction can't be done.*

Keywords: *Ultrasound (US); iatrogenic sciatic nerve injury, nerve conduction studies (NCS); cross sectional area (CSA); tibial and common peroneal nerves; peroneus muscles, calf muscles and posterior thigh muscles.*

INTRODUCTION:

The sciatic nerve is among the largest peripheral nerves in terms of thickness within the body. The nerve comes from the ventral rami of spinal nerves spanning from L4 to S3 and comprises fibers from both the posterior and anterior divisions of the lumbosacral plexus. Once the nerve fibers exit the lower vertebrae, they come together and merge to create a unified nerve. The greater sciatic notch is the exit point of the nerve from the pelvic cavity. The pudendal nerve, the posterior femoral cutaneous nerve, the inferior gluteal vessels, and the internal pudendal vessels are the other anatomical structures that accompany or run alongside this nerve at this particular location(1). While the reporting frequency has decreased compared to previous years, iatrogenic injuries resulting from intramuscular (IM) injections remain prevalent. The buttock is a common site for intramuscular injections, which often lead to injuries in the sciatic nerve due to its large size. The potential outcomes of an injury caused by injecting the sciatic nerve are severe and can lead to significant neurological and medico-legal issues(2).

The Nerve Conduction Study (NCS) is considered the benchmark for assessing muscle denervation in peripheral neuropathy(3). Regrettably, NCS can cause discomfort for patients because the electrical impulses are not suited for many patients. Moreover, to obtain accurate results during this test, it is essential to have the patient's cooperation(4). However, it is not suitable for the acute phase. The complete Wallerian degeneration takes approximately two weeks, and the maximum diagnostic information becomes accessible. Furthermore, electro-diagnostic testing is unable to determine the precise location of the lesion site in individuals experiencing a complete absence of nerve conduction (5). That's why interest in high-resolution ultrasonography (US) is increasing(6). Because ultrasonography provides high-quality images of nerves and allows clinicians to evaluate them along their anatomical course, it provides important information on the origin and precise location of most lesions. Also, ultrasonography allows real-time dynamic(7) and real-time static information concerning the peripheral nerves and their surrounding tissues(8).

US can also be utilized to examine the morphological alterations associated with such injuries(8). Transverse imaging is routinely conducted to identify the anatomical location of the specific nerve under examination and to evaluate its size and structure for any abnormalities. As per the international agreement, the most efficient way to gauge the size of a nerve is by assessing its cross-sectional area (CSA) as it is followed along the distinctively bright outer epineural rim(5). High-resolution ultrasonography permits direct imaging of the peripheral nerves, including the sciatic nerve. The proximal part of the normal sciatic nerve has a greater cross-sectional area, which declines as the nerve courses distally(9). Additionally, musculoskeletal US is a noninvasive technique that is widely accessible. Ultrasonography offers the benefit of delivering real-time and dynamic patient information as well(10). Neuromuscular disorders can be identified through musculoskeletal ultrasonography, which can detect a reduction in muscle thickness. US can also detect fibrosis and fatty atrophy of muscle(11).

The use of ultrasonography imaging allows for the evaluation of skeletal muscle quality(12). The muscle tissue typically appears echogenic, allowing ultrasound to easily penetrate it, while the fibrous tissue reflects ultrasound waves. Ultrasonography enables the utilization of echo intensity (EI) to showcase changes resulting from heightened adipose tissue and intramuscular fibers. Muscle tissue becomes heterogeneous and hyperechoic due to fat replacement and muscle atrophy, increasing the EI. Thus, muscle EI increases with denervated muscles(13). Muscle changes attributed to neuropathy have been proposed to be indicated by elevated muscle echo intensity(11).

AIM OF THE WORK:

This study aimed to clarify the role of ultrasound (US) in the assessment of the sciatic nerve injury in correlation of electrophysiological studies .

PATIENTS AND METHODS:

This prospective study was performed from March 2023 to December 2023 in the Department of Radiodiagnosis of Ain Shams University's hospitals and the Department of Physical Medicine & Rehabilitation at institute of neuro-motor system. The study included 40 children with unilateral limping or paresthesia of lower limb with history of intramuscular injection in the buttocks. Children aged 2-10 years were included with no gender selection. Children older than 10 years and patients with other sciatic nerve injuries (history of trauma, neuromuscular disease, muscle disease and history of intervention that cause the injury to the sciatic nerve) were excluded from our study.

The following procedures were applied to all patients: informed written consent from the parents denoting agreement to enrolment in the study, full history taking as regards the onset, duration, character, precipitating factors, as well as associated symptoms. In addition, clinical evaluation as done and followed by real-time high-resolution ultrasonography and nerve conduction studies for the affected limb and the normal contralateral limb.

Real-time high-resolution ultrasonography:

All imaging was conducted using the LOGIQ P7 (GE health care, south coria), which utilizes a high-resolution transducer, following clinical diagnosis with (6-12) MHz linear probes and 11-18 MHz linear array transducer (Aplio 400; Toshiba Medical system co, Ltd, Tokyo, Japan) The patients were examined in a prone position using conventional B-mode. A standardized, preprogrammed scanning protocol (with optimized B-mode scanning parameters such as depth, frequency and focal zone) were used to ensure the consistency of the results obtained. All scans covered the whole length of sciatic nerve and muscles from the popliteal fossa up to the greater sciatic notch. The nerve was localized in the short and long axis, to see the contour, architecture, caliber and integrity of the injured sciatic nerve segment and measuring CSA in maximum diameter and compared with the normal side.

Nerve conduction studies:

Nerve conduction studies were performed using Neuro - MEP electrodiagnostic equipment (NEUROSOFT, Voronin str., Ivanovo, Russia). The patient was lying on their back. The ground electrode was connected to the limbs that needed to be examined, ideally positioned between the electrodes used for stimulation and recording. The tibial nerve CMAP was recorded from the abductor hallucis muscle and the peroneal nerve CMAP from both the extensor digitorum brevis and the tibialis anterior (TA) muscles. The recording electrodes were positioned at a distance of 10 cm and 8 cm from the site of stimulation for the tibial and peroneal nerves, respectively. The reference electrode was placed 3_4cm distal to recording electrode in bone or tendon (not muscles). The result of the affected limb was compared to the normal limb.

Statistical methods:

IBM SPSS statistics (V. 27.0, IBM Corp., USA, 2020) was used for data analysis. In addition to providing numerical values and percentages for categorized data, the date was represented using the median and percentiles for quantitative non-parametric measures. Wilcoxon Rank Sum test was used to compare two independent groups for non-parametric data; while, Wilcoxon signed rank test was used to compare two dependent groups when the data is non-parametric. Ranked Spearman correlation test was also used to examine the potential relationship between two variables within each group, specifically for non-parametric data. An error probability of 0.05 was deemed significant, whereas probabilities of 0.01 and 0.001 were considered highly significant.

Ethical consideration:

This study protocol was approved by our institutional review board and carried out in compliance with our university's Ethics Committee rules. Ain Shams University Faculty of Medicine's Regional Ethical Committee granted their approval for our study (MS 156/2023). Throughout all phases of the study, participants' privacy and confidentiality will be protected.

RESULTS:

The study included 40 symptomatic patient, 25 males (62.5%) and 15 females (37.5%), their age ranged from 2 to 6 years with a median age of about 4 Years. The affected limbs were of left side in 52.5%; while, of right side in 47.5%. The length of time that the affected nerves were injured varied from 2 days to 4 years. All patient giving history of immediate onset of complaint after intramuscular injection. Ultrasound examination was done for all patient by comparing the affected side with the normal side. Thus, the cases group included the affected 40 limbs; whereas, the controls group included the normal 40 limbs.

The cases group and the controls group were subjected to parameter analysis in gray scale Table (1). The cases group exhibited a significantly larger CSA compared to the controls group, with median values of 28 mm^2 and 13 mm^2, respectively. This difference was found to be highly statistically significant, as indicated by a p-value of 0.

Table 1: Sciatic nerve CSA in cases group and controls group.

	Group	n	Median	25 Perc	75 Perc	Z	p	Sig.
Sciatic nerve CSA	Cases	40	28	21.25	37.5			
	Controls	40	13	10	16	-5.513b	0	HS

The affection of the nerve was increased in CSA and loss of fascicular pattern in cases group as compared to the controls group Table (1).

On the other hand, the muscles affection was fatty infiltration and decreased circumference. Alternatively, the most affected muscles in ultrasound finding were as follows: peroneus muscles (25 patients; 62.5%), the calf muscles (19 patients; 47.5%) and posterior thigh muscles (14 patients; 35%) Figure (1).

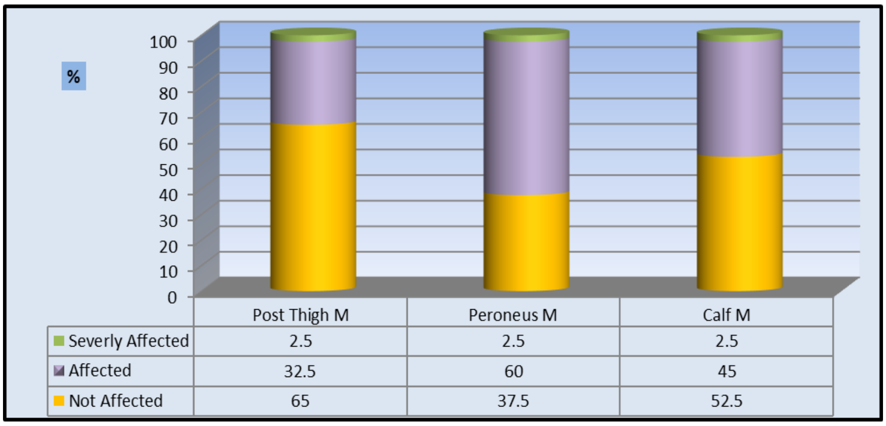

Figure 1: Percentage muscles affected in cases group.

The longer the duration, the more the affection of muscles. The muscles in the acute phases did not have the time to be affected; while, the muscles in longer duration were severely affected as shown in Tables (2-4).

Table 2: Relation between peroneus muscle affection and the duration of IM injection:

	Peroneus muscle	n	Median	25 Perc	75 Perc	Z	p	Sig.
Duration of IM Injection	0	15	0.5	0.1	1.25	-3.265	0.001	HS
	1	24	1.25	1	2.925			

(0) not affected while (1) affected (fatty infiltration and reduce girth)

The peroneus muscle was the muscle that experienced the greatest impact, and was also the muscle that was affected in a short duration. There was highly significant decreased median between peroneus muscle (0) in comparison to (1) as regards duration of IM injection with p value 0,001.

Table 3: Relation between calf muscle and the duration of IM injection:

	Calf muscle	n	Median	25 Perc	75 Perc	Z	p	Sig.
Duration of IM Injection	0	21	0.5	0.225	1.25	-2.762	0.006	HS
	1	18	1.25	1	2.775			

(0) not affected while (1) affected (fatty infiltration and reduce girth)

Also, the calf muscle took short duration to be affected but this muscle group was affected lesser than peroneus muscle group. There was highly significant decreased median between calf muscle (0) in comparison to (1) as regards duration of IM injection with p value. 0,006.

Table 4: Relation between posterior thigh muscle and the duration of IM injection:

	Posterior thigh muscle	n	Median	25 Perc	75 Perc	Z	p	Sig.
Duration of IM Injection	0	26	0.75	0.25	1.25	-3.729	0	HS
	1	13	2.3	1.25	5			

(0) not affected while (1) affected (fatty infiltration and reduce girth)

The posterior thigh muscle aseemed to be the last to be affected as the muscle took longer duration to be affected with median 2.3 months. There was highly significant decreased median between posterior thigh muscle (0) in comparison to (1) as regards duration of IM injection with p value 0.

As regarding the electrophysiological studies of the affected and normal sides, there were highly significant decreased median among affected side in comparison to the normal side as regards the distal latency of tibial nerve with p value 0, amplitude of tibial nerve with p value 0, distal latency of peroneal nerve with p value 0.002, amplitude of peroneal nerve with p value 0 and latency of F wave of peroneal nerve with p value 0. In addition, there was non-significant change between affected & normal as regards conduction velocity of tibial nerve, Latency of F wave tibial nerve and conduction velocity of peroneal nerve with p value >0,05.–Moreover, there was significant correlation in the parameters of NC comparing normal and affected limb. Reduced amplitude regarding tibial and peroneal nerves were also observed in the affected limb (P=0 for both). Eventually, only 23 patients (71%) tested positive for sciatic nerve injury in the standard NCS, and the electrophysiological findings did not correspond with the ultrasonography measurements. Overall, in the control groups (normal limb), no nerve or muscles abnormalities were detected by either NC or US.

Table 5: The finding by electrophysiological studies

		Median	25 Perc	75 Perc	Z	p	Sig.
Distal latency of tibial nerve	Affected limb	3.05	2.3475	4.1875	-4.390b	0	HS
	Normal limb	4.7	3	5.125			
Amplitude of tibial nerve	Affected limb	0.513	0.2075	4.115	-3.940b	0	HS
	Normal limb	5.9	5.1	8.63			
Conduction velocity of tibial nerve	Affected limb	42.7	31.7	54	-1.808b	0.071	NS
	Normal limb	47.8	38.15	53.5			
Latency of F wave tibial nerve	Affected limb	27.9	0	40	-1.153b	0.249	NS
	Normal limb	35	28.9	43.15			
Distal latency of peroneal nerve	Affected limb	2.72	2.3	4.2825	-3.028b	0.002	HS
	Normal limb	4.5	2.9625	6.2075			
Amplitude of peroneal nerve	Affected limb	1.9	0.1235	3.2475	-4.330b	0	HS
	Normal limb	3.2	2.39	5.025			
Conduction velocity of peroneal nerve	Affected limb	45.95	32.925	52.975	-1.235b	0.217	NS
	Normal limb	45.5	32.9125	53.25			
Latency of F wave of peroneal nerve	Affected limb	23.9	2.4	29	-3.689b	0	HS
	Normal limb	36	24.575	42.45			

Illustrative cases:

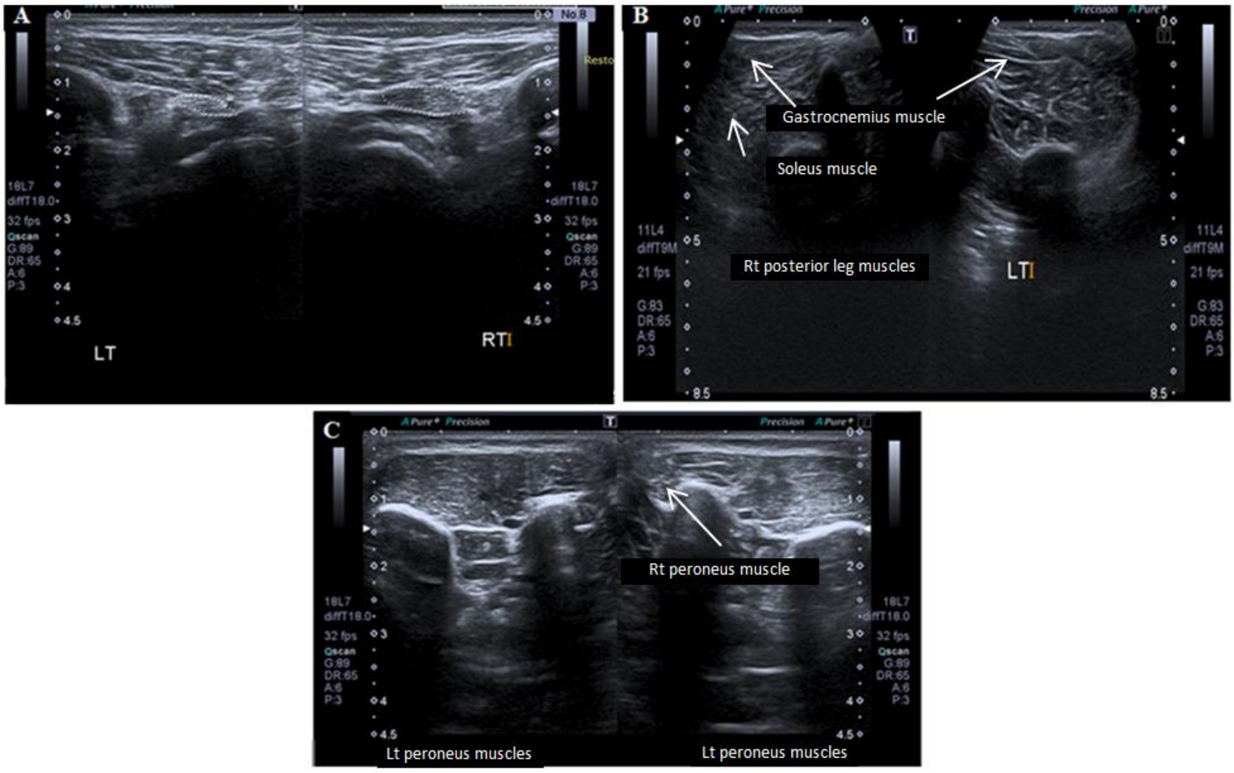

Figure 2: (A) Transverse sonogram for sciatic nerve of both lower limb in the buttocks between greater trochanter and ischeal tuberosity in 4 years old male patient with history of 9months intramuscular injection in the right buttocks, NCS revealed reduced tibial nerve amplitude while normal peroneal nerve amplitude. US reveals increase in CSA of sciatic nerve in the right buttocks in comparison to the normal limb, in the affected right side CSA of sciatic nerve (0.38cm ^{2}) while in normal left buttocks CSA (0.16 cm^2), **(B)** Comparison between leg muscles in both limbs reveals highly affection of leg muscles in the right side by fatty infiltration and reduced girth. **(C)** Comparison between peroneus muscles in both limbs reveals affection of the muscles by fatty infiltration and reduced girth in the right affected side.

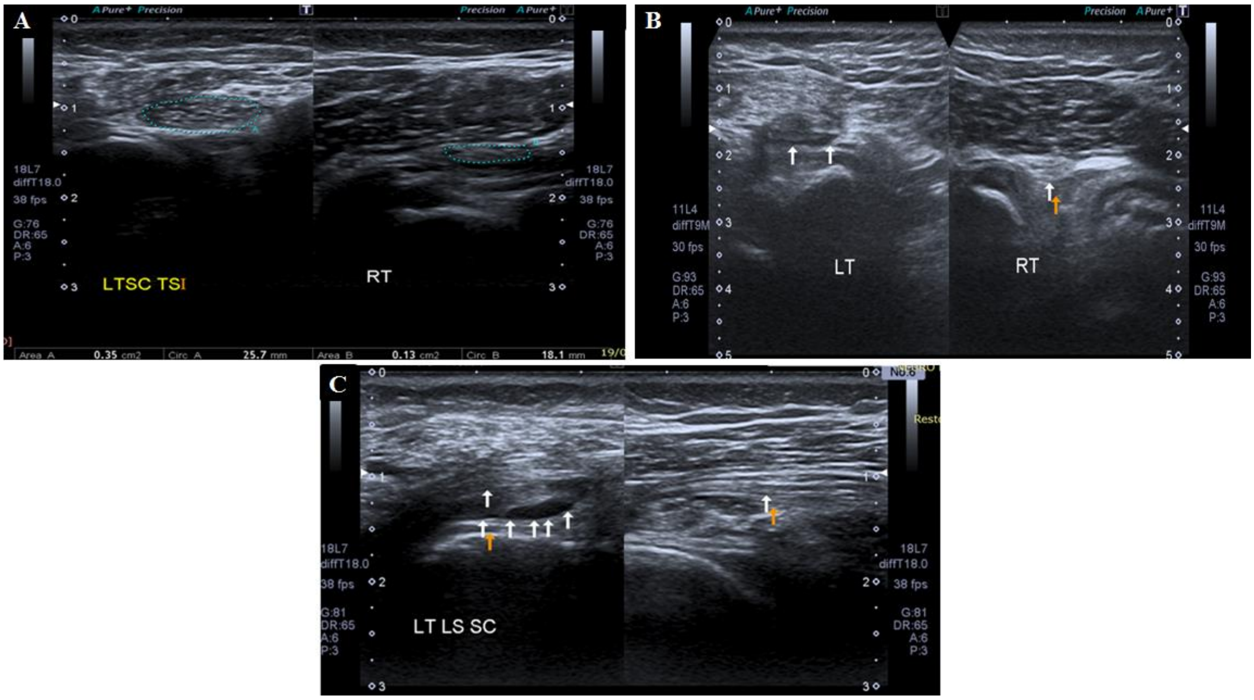

Figure 3: (A) Transverse sonogram for sciatic nerve of both lower limb in the buttocks in 3 years old female patient with history of one month and half intramuscular injection in the left buttocks, NCS revealed reduced tibial nerve amplitude while normal peroneal nerve amplitude.US reveals increase in CSA of sciatic nerve in the right buttocks in comparison to the normal limb, in the affected left side CSA of sciatic nerve (0.35 cm ^{2}) while in normal left buttocks CSA (0.13 cm^{2}). **(B)** Transverse section of both limb reveals hypoechogenic rim around the affected sciatic in the left limb with increase in CSA. **(C)** Longitudinal sonogram in the buttocks in both limbs reveal increase thickness with hypoechogenic rim (multiple arrows) in the affected left limb.

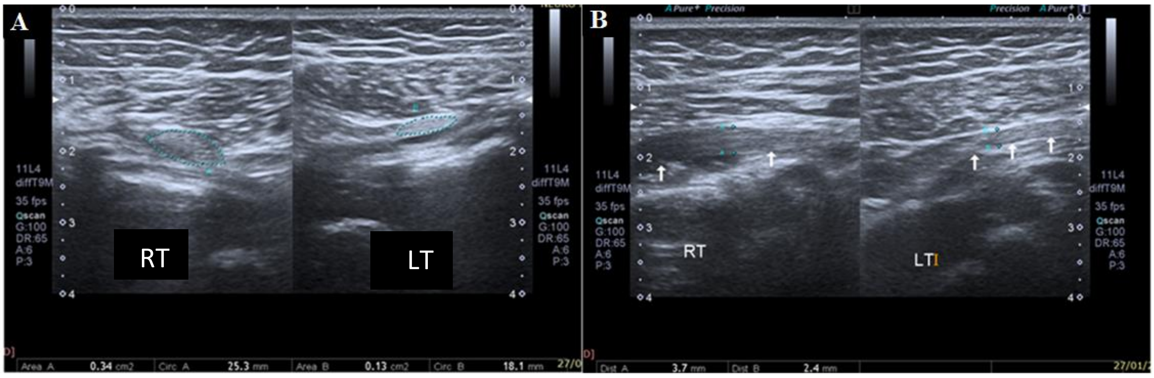

Figure 4: (A) Transverse sonogram for sciatic nerve of both lower limb in buttocks in 2 years old male patient with history of one month and half intramuscular injection in the right buttocks ,with normal NCS .US reveals increase in CSA of sciatic nerve in the right buttocks in comparison to the normal limb, in the affected right side CSA of sciatic nerve (0.34cm^{2}) while in normal left buttocks CSA (0.13 cm^{2}), **(B)** Longitudinal sonogram in the buttocks in both limbs reveal increase thickness in the right side .

DISCUSSION:

The second most common mononeuropathy in the lower limb, following common peroneal nerve injury, is sciatic neuropathy. The potential for nerve damage arises from the lengthy anatomical trajectory of the nerve, which begins at the lumbosacral plexus, passes through the sciatic notch, and extends to its division just above the popliteal fossa. One of the main reasons of reported cases of sciatic nerve damage worldwide has been identified as improperly administered injections and a lack of workers who are sufficiently trained and proficient in providing parenteral drugs[14].

Almost 90% of individuals diagnosed with SNII (sciatic nerve injection injury) experience symptoms that manifest immediately. A delayed onset, occurring within minutes to hours after the injection, is observed in approximately 10% of patients. The variation observed might be attributed to the site where the injection is administered. The symptoms of intraneural injection seem to manifest immediately, while delayed onset could be associated with the injection being placed near the nerve or within the epineurium. This can result in central diffusion and gradual harm to the fascicles over a period of time[15].

Our study included 40 patients (80 limbs) (40 affected limb (cases group) and compared with 40 normal limbs (controls group). In the current study, US confirmed the clinical diagnosis of sciatic nerve injury in all included patients. This goes in agreement with the results of the study of *Lee et al.,*[16] as high-resolution ultrasonography accurately diagnosed and pinpointed the location of lesions in 100% of examined cases. However, only 23 patients (71%), had positive nerve conduction studies (NCS).

It has been found that injuries to the peroneal division of the sciatic nerve occur more often than to the tibial division attributed to several factors: the peroneal division's position is more lateral, it has less protective connective tissue surrounding it, and the nerve's pathway is relatively more fixed or tethered[15]. This goes in agreement with our study results that showed the most affected muscles were the peroneus muscle group which supplied by peroneal nerve (25 patients; 62.5 %). In addition, *Singh et al.*[9] found that there is no correlation between CSA and age (p >0.05) which is consistent with our study result.

Our study was not without limitations comprising small sample size of the patient, wide range of duration from injection and wide range of age as the children. In addition, participants who had a brief duration of injury were included based on clinical judgment without undergoing nerve conduction studies (NCS). Also, no attempt was made to correlate the grades between the US and NCS results. Although, EMG is the best for muscle assessment to correlate with US finding for muscles EMG wasn't done as it is very painful and need patient to be very cooperative for muscle actions but in our study patient group very young to be cooperative.

CONCLUSION:

Ultrasound is considered the first-line confirmatory test in clinically suspected iatrogenic sciatic nerve injury since it can confirm the clinical diagnosis and detect the lesion's exact location, especially in the acute stage when nerve conduction studies (NCS) cannot be performed.

Recommendations:

We recommend further studies with more patients’ number with decreased range of age of the included patients to minimize the difference in result especially in NCS because patient above 4 years old have the normal number level, while in the age of 2 they have the half number of normal levels. Also, the classification of degree of clinical symptoms with the degree of affection in US and NCS should be evaluated as well as the duration of injury should be specific whether chronic only or acute only. Finally, US image interpretation should be done by two experienced radiologists who are blinded to each other's findings to increase the ratability of the result.

Declaration:

Conflicting interest:

The authors affirm that they have no conflicts of interest.

Funding:

No funding was provided for this research by any public, commercial, or non-profit organization

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دور الموجات فوق الصوتية عالية الدقة في تقييم إصابات العصب الوركي علاجي المنشأ في الفئة العمرية للأطفال فى الارتباط مع الدرسات الفيزيولوجيهة الكهربية

مارى سمير صموئيل ابادير[1] وحنان محمود حسين عرفه [1]وسعاد سعيد احمد الملا[2]
ونهى محمد جمال الدين محي[1]
قسم الأشعة التشخيصية - كلية الطب جامعة عين شمس- القاهرة - مصر [1]
قسم روماتيزم وتأهيل - معهد الجهاز العصبي الحركي- الجيزه - مصر [2]

يعد العصب الوركي من أكبر الأعصاب الطرفية من حيث السُمك داخل الجسم. يمكن أن يؤدي حقن عضلات المؤخره الى مشكلة علاجية المنشأ تعرف باسم إصابة العصب الوركي، والتي يمكن أن تؤدي إلى مضاعفات صحية ملحوظة. قد يؤدي إلى أعراض مختلفة من تنمل خفيف إلى عواقب عصبية خطيرة. الدراسات الفيزيولوجية الكهربية هي الطرق القياسية لتقدير إصابة العصب المحيطي، والتي يمكن أن توفر معلومات تشخيصية مفيدة.

توضيح دور الموجات فوق الصوتية في تقييم إصابة العصب الوركي ومقارنتها بالجانب الطبيعي مع ارتباط الدراسات الفيزيولوجية الكهربية.

البحث المعني عبارة عن دراسة عرضيه، وشملت 40 مريضا (كلا الطرفين) تم فحصهم (80 طرفا)). وتراوحت أعمار المرضى من سنتين إلى 6 سنوات. ونسبة الذكور 62.5% مقابل 37.5% إناث. وكانت الأطراف المصابة 52.5% في الجانب الأيسر و47.5% في الجانب الأيمن. تم إجراء فحص الموجات الصوتيه وكان المرضى منبطحين وأطرافهم السفلية مكشوفة. تم تسجيل معلمات الموجات فوق الصوتية من خلال مقارنة الطرف المصاب بالطرف الطبيعي. تم إجراء دراسات التوصيل العصبي عن طريق تسجيل الأعصاب الشظوية الظنبوبية والمشتركة ومن ثم مقارنتها مع الأطراف الطبيعية.

أكدت الموجات الفوق صوتيه بنسبة 100% التشخيص السريري للعصب الوركي بينما أكد رسم العصب تشخيص 71% من إصابات العصب الوركي التي تم تشخيصها سريرياً.

لا توجد علاقة بين رسم العصب والموجات الصوتيه في تقييم إصابة العصب الوركي علاجي المنشأ.

يمكن استخدام الموجات فوق الصوتيه كتصوير أولي مفضل لتقييم إصابة العصب الوركي خاصة في الفتره الاولى عندما يتعذر إجراء توصيل العصب.