RESEARCH

# ROLE OF HIGH-RESOLUTION ULTRASOUND IN THE EVALUATION OF PERIPHERAL NERVE LESIONS

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## Abstract

**Background:** High-resolution ultrasound has been used as an important tool in the diagnosis, management and monitoring of both acute and chronic peripheral nerve injuries. The aim is to Role of high resolution ultrasound in the evaluation of peripheral nerve lesions. **Materials and Methods:** It is cross sectional study referred to Department of radiodiagnosis. Study done in 50 patients with clinical suspicion of peripheral nerve lesions had high resolution ultrasonography of suspected peripheral nerves was performed. The ages of the patients ranged between 11 to 60 years. **Result:** Traumatic peripheral nerve injuries occur from a variety of causes and their prevalence among patients who have had a traumatic injury is approximately 2.8%. Out of 18 peripheral nerves 7 were median nerve,4 were ulnar nerves,3 are sural nerve and one each of CPN, PTN, superficial radial nerve and brachial plexus. . It was normal in 9 cases, showed partial discontinuity in 5 cases, and showed complete discontinuity in 4 cases, suggestive of complete transection of the nerve. The profile of the 8 leprosy patients with total of 86 nerves were examined in the study. 3 patients had borderline tuberculoid, 1 patients had mid borderline, and 2 patients had borderline lepromatous, 1 patients had lepromatous leprosy and 1 patient had polyneuritic type. Maximum patients (37%) had BT type of leprosy. Significantly enlarged nerves with a CSA.110 mm2 were observed in 2 nerves (2 Ulnar N). Maximum percentage (50%) of the patients had an ulnar nerve thickened in the range of 3-3.9mm. 25% of the patients had a significant thickening of 5 mm and above. In the remainder 13.7% nerves showed mild, 7.5% nerves moderate and 10% nerves showed severe reduced echo reflectivity. The 10 peripheral nerve sheath tumors in our study comprised 5 schwannomas and 5 neurofibromas. The locations of the tumors were ulnar nerve (n = 6), median nerve(n = 1),superficial radial nerve(n=2) , lateral cutaneous nerve of thigh(n=1). **Conclusion:** Ultrasound facilitated surgical planning in patients with neuromas, foreign bodies, and postfracture complications, allowing for targeted surgery and avoiding wide accesses for exploration because of accurate localization and estimation of nerve damage.

## INTRODUCTION

Before the introduction of imaging methods the diagnostic work-up of peripheral nerve disorders was based only on evaluation of the clinical history, neurological examination and standard electrodiagnostic examination, consisting of nerve conduction studies, recording of late responses (F-waves) and needle electromyography. Nerve imaging became an important method in patient management by providing information on lesion morphology, anatomic location, relationship of lesions to surrounding soft tissue, and evaluation of areas difficult to access with electrodiagnostic methods. Imaging can also identify peripheral nerve lesions that are not apparent on electrodiagnostic testing. High resolution ultrasound (HRUS) and magnetic resonance imaging (MRI, MR-Neurography) are the most commonly used methods for visualizing peripheral nerves.[1]

Ultrasound (US) modified diagnostic and therapeutic management beyond the electrodiagnostic findings. US complements neurophysiological assessment even in routine practice, and this confirms the increasing interest in US in a multidimensional evaluation of peripheral


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nervous system diseases. Types of peripheral nerve abnormalities suited for visualization by HRUS include changes in nerve caliber, continuity, echogenicity, echotexture, and vascularisation. Imaging can identify peripheral nerve tumours, traumatic lesions, entrapments with nerve damage, inflammation, demyelinating features, infections, and it can be used for imaging-guided interventions, such as nerve blocks, biopsies or therapeutic application of drugs.[2,3] Intraoperative HRUS can show the extent of traumatic peripheral nerve lesions, it appears to be capable of assessing the type (intraneural/perineural) and grade of nerve fibrosis, and in combination with intraoperative neurophysiological studies it is an important tool for the non-invasive assessment of the regenerative potential of a nerve lesion. Role of high-resolution ultrasound in the evaluation of peripheral nerve lesions.

## MATERIALS AND METHODS

It is cross sectional study referred to Department of radiodiagnosis, Osmania medical College/hospital for high resolution Ultrasound for suspected cases of peripheral nerve lesions. Study done from December 2018 to October 2020 in 50 patients

**Inclusion criteria:** patient with suspected peripheral nerve lesions

**Exclusion criteria:** Patients with unstable general conditions

Before starting the scan of a peripheral nerve in a particular region, one needs to know the detailed anatomy. All examinations are performed with either SAMSUNG RS80A/ESOATE MY LAB CLASS-C usg scanners with high frequency linear probe. The examination is started from a known anatomic landmark near the nerve. Once the nerve is localized in the short axis, it is traced cranially and caudally to see for contour and architectural abnormality. If pathology is encountered, then the attention is focused on that particular segment. The probe is then turned in the long axis of the nerve and the pathology is evaluated. USG gel should be used liberally. This helps to avoid missing the nerve while tracing it. Use of focal zone and depth optimally dramatically improves the quality of the image. Nerves generally run along borders of other structures, especially between different muscle groups. Movement of limb helps to differentiate nerve from tendons, whereas color Doppler helps to differentiate nerves from vessels.

## RESULTS

Age distribution chart shows peak incidence between 21to 30 and between 31 to 40 years. Females are most effected age group in study.

**Table 1: Sex group distribution in different age groups**

| Age | Males | Females |
|---|---|---|
| 11 to 20 yrs | 3 | 2 |
| 21 to 30 yrs | 7 | 8 |
| 31 to 40 yrs | 6 | 9 |
| 41 to 50 yrs | 2 | 6 |
| 51 to 60 yrs | 6 | 1 |
| Total | 24 | 26 |

**Table 2: Cases with history of trauma**

| History trauma | Number of cases | percentage |
|---|---|---|
| Present | 18 | 36% |
| Absent | 32 | 64% |
| Nerve distribution in cases of trauma | | |
| Median nerve | 7 | 38.8% |
| Ulnar nerve | 4 | 22.2% |
| Superficial radial nerve | 1 | 5.5% |
| Brachial plexus | 1 | 5.5% |
| Common peroneal N | 1 | 5.5% |
| Posterior tibial nerve | 1 | 5.5% |
| Sural nerve | 3 | 16.6% |

In our study, remote traumatic injuries involving 18 peripheral nerves were studied. Out of 18 peripheral nerves 7 were median nerve,4 were ulnar nerves,3 are sural nerve and one each of CPN, PTN, superficial radial nerve and brachial plexus.

**Table 3: Sonographic finding of nerve in cases**

| Nerve discontinuity | Number of cases | percentage |
|---|---|---|
| Present | 09 | 50% |
| Absent | 09 | 50% |
| Traumatic Neuroma | | |
| Present | 11 | 61% |
| Absent | 7 | 39% |
| Endbulb Neuroma | | |
| Present | 03 | 17% |
| Absent | 15 | 83% |
| Neuroma in continuity | | |
| Present | 08 | 44% |
| Absent | 10 | 56% |
| Entrapment Neuropathy | | |
| Present | 12 | 24% |
| Absent | 38 | 76% |
| Total | 50 | 100% |
| Nerve vascularity | | |
| Present | 08 | 67% |
| Absent | 04 | 33% |
| Total | 12 | 100% |

It was normal in 9 cases, showed partial discontinuity in 5 cases, and showed complete discontinuity in 4 cases, suggestive of complete transection of the nerve. 11 of the injured nerves showed neuroma which results from random proliferation of axons, Schwann cells and fibroblasts, admixed together to form a non-neoplastic mass. Out of this, 3 were end neuroma seen in patients with complete transection of the nerve, and the others were neuromas in continuity seen in patients with partial transection of the nerves. All the 7 patients with median nerve involvement manifesting as carpel tunnel syndrome showed central intraneural vascularity. Nerve edema was found in 6cases with median nerve entrapment (85%) while absent in one case (14%). Flattening of


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median nerve was found in all the cases . Bowing of flexor retinaculum was seen in 5 cases (71%) and absent in 2 cases (28%).

**Table 4: Finding of nerve involement in specific nerves.**

| Finding of nerve transection in specific nerves in trauma cases | Number of cases | Percentage |
|---|---|---|
| Ulnar nerve | 02 | 22.2% |
| Median nerve | 03 | 33.3% |
| Sural nerve | 03 | 33.3% |
| Superficial radial N | 01 | 11.1% |
| Total | 09 | 100% |
| Specific nerve involvement in traumatic neuroma cases | | |
| Nerve | | |
| Median Nerve | 05 | 46% |
| Ulnar Nerve | 03 | 27% |
| Superficial Radial Nerve | 01 | 9% |
| Brachial Plexus | 0 | 0% |
| Posterior Tibial Nerve | 01 | 9% |
| Common Peroneal Nerve | 01 | 9% |
| Sural Nerve | 0 | 0% |
| Specific nerves involved in entrapment neuropathy | | |
| Carpel Tunnel Syndrome | 07 | 58% |
| Cubital Tunnel Syndrome | 01 | 8% |
| Supinator Syndrome | 02 | 17% |
| Radial Tunnel Syndrome | 02 | 17% |
| Total | 12 | 100% |

Two patients had bilateral carpal tunnel syndrome. Three patients had right side involvement and two had left side involvement. Majority of patients had symptoms of less than 6 months duration. Most common symptom was pain in the hand followed by numbness in lateral 3 1/2 fingers. Majority of the patients in the study underwent surgical treatment (11 cases).

**Table 5: Sonographic finding of nerve edema in entrapment neuropathies**

| Nerve | Nerve Edema | |
|---|---|---|
| | Present | Absent |
| Median Nerve | 6 | 1 |
| Ulnar Nerve | 1 | 0 |
| Posterior Interosseous N | 1 | 1 |
| Radial Nerve | 1 | 1 |

All the 7 patients with median nerve involvement manifesting as carpel tunnel syndrome showed central intraneural vascularity. Nerve edema was found in 6cases with median nerve entrapment (85%) while absent in one case (14%). Flattening of median nerve was found in all the cases . Bowing of flexor retinaculum was seen in 5 cases (71%) and absent in 2 cases (28%).

**Table 6: Distribution of cases among various types of leprosy**

| Nerve Involved | Number of cases | Percentage |
|---|---|---|
| Ulnar Nerve | 11 | 12.7% |
| Median Nerve | 10 | 11.6% |
| Superficial Radial Nerve | 06 | 6.9% |
| Common Peroneal Nerve | 06 | 6.9% |
| Posterior Tibial Nerve | 05 | 5.8% |
| Brachial Plexus (Trunks) | 06 | 6.9% |
| Total Nerves Examined | 86 | 100% |

**Table 7: Maximum and mean CSA of individual nerves examined in leprosy**

| Maximum CSA of individual nerves examined in leprosy | Maximum CSA(mm2) |
|---|---|
| Ulnar Nerve | 112mm2 |
| Median Nerve | 31mm2 |
| Superficial Radial Nerve | 12mm2 |
| Common Peroneal Nerve | 26mm2 |
| Posterior Tibial Nerve | 38mm2 |
| Brachial Plexus (Trunks) | 17mm2 |
| Mean CSA of individual nerves examined in leprosy | |
| Ulnar Nerve | 30mm2 |
| Median Nerve | 17mm2 |
| Superficial Radial Nerve | 3.5mm2 |
| Common Peroneal Nerve | 14.5mm2 |
| Posterior Tibial Nerve | 15mm2 |
| Brachial Plexus (Trunks) | 10mm2 |

Mean cross sectional area of median nerve at the carpel tunnel of patients suffering from carpel tunnel syndrome was 13.9mm2 which showed statistically significant difference compared to standard reference values.

**Table 8: Number of nerves with specific sonographic findings in leprosy**

| Sonographic Finding | No of Nerves | Percentages |
|---|---|---|
| Nerve Thickening | 44 | 51% |
| Loss of Fascicular Echo Pattern | 40 | 46% |
| Intraneural Vascularity | 24 | 28% |
| Nerve Abscess | 03 | 3% |
| Intraneural Calcifications | 01 | 1% |
| Total Nerves Examined | 86 | 100 |

The most common sonographic features observed in nerve trauma was nerve thickening, which was noted in most of the cases. The epineurium was seen as an echogenic line surrounding the nerve, and could be identified in all the cases.

**Table 9: Individual nerves involved in peripheral nerve sheath tumors**

| Nerve Involved | Neurofibroma Number (%) | Schwannoma Number (%) |
|---|---|---|
| Ulnar Nerve | 02 (40%) | 04 (80%) |
| Median Nerve | 00 | 01 (20%) |
| Superficial Radial Nerve | 02 (40%) | 00 (0) |
| Lateral Cutaneous Nerve of Thigh | 01 (20%) | 00 (0) |
| Total | 05(100%) | 05(100%) |

**Table 10: Individual sonographic findings in cases with neurofibroma and schwannoma**

| Neurofibroma | Number of Cases | Percentages |
|---|---|---|
| Central Mass Lesion | 05 | 100% |
| Eccentric Mass Lesion | 00 | 0 |
| Accoustic Enhancement | 04 | 80% |
| Cystic Areas | 00 | 0 |
| Lesion Vascularity | 02 | 40% |
| Schwannoma | | |
| Central Mass Lesion | O1 | 20% |
| Eccentric Mass Lesion | 04 | 80% |
| Accoustic Enhancement | 04 | 80% |


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| | | |
|---|---|---|
| Cystic Areas | 03 | 60% |
| Lesion Vascularity | 02 | 40% |

## DISCUSSION

From December 2018 to October 2020, 50 patients with clinical suspicion of peripheral nerve lesions were referred to our department and high-resolution ultrasonography of suspected peripheral nerves was performed. Out of 50 patients 18 cases were of peripheral nerve traumatic injury, in 12 cases entrapment neuropathy was identified, 8 cases were of leprosy neuritis, in 10 cases peripheral nerve sheath tumors were identified, mortons neuroma was found in 2 cases.

The ages of the patients ranged from 11 to 60 years with peak incidence being in the age group of 21 to 30 years and 31 to 40 years. This data is agreed by most of the previous studies done earlier. Traumatic peripheral nerve injuries occur from a variety of causes and their prevalence among patients who have had a traumatic injury is approximately 2.8%. Such injuries are increasingly recognized because of improved trauma services. In our study, remote traumatic injuries involving 18 peripheral nerves were studied. Out of 18 peripheral nerves 7 were median nerve,4 were ulnar nerves,3 are sural nerve and one each of CPN, PTN, superficial radial nerve and brachial plexus. The nerve which was suspected to be injured could be identified in all cases and sonographic features correlated with clinical symptomatology. Other studies have also reported a high sensitivity and specificity for the detection of peripheral nerve injury by sonography. The most common sonographic features observed in nerve trauma was nerve thickening, which was noted in most of the cases. The epineurium was seen as an echogenic line surrounding the nerve, and could be identified in all the cases. It was normal in 9 cases, showed partial discontinuity in 5 cases, and showed complete discontinuity in 4 cases, suggestive of complete transection of the nerve. 11 of the injured nerves showed neuroma which results from random proliferation of axons, Schwann cells and fibroblasts, admixed together to form a non-neoplastic mass. Out of this, 3 were end neuroma seen in patients with complete transection of the nerve, and the others were neuromas in continuity seen in patients with partial transection of the nerves. The neuroma appeared as an irregular hypoechoic structure within the nerve at the site of trauma with no internal vascularity. The imaging appearance of a traumatic neuroma in our study was the same as described in previous studies.

The profile of the 8 leprosy patients with total of 86 nerves were examined in the study. 3 patients had borderline tuberculoid, 1 patients had mid borderline, and 2 patients had borderline lepromatous, 1 patients had lepromatous leprosy and 1 patient had polyneuritic type. Maximum patients (37%) had BT type of leprosy . Skin smears were positive in 7 patients. Clinical thickening, ranging from grade I,II & III, was observed in examined nerves. In our study 14% had grade I, 7.8% had grade II, and 3.1% had grade III nerve thickening and 75% grade 0 on general clinical examination. It was seen that 75% of ulnar nerve cases had no tenderness on general examination. The nerves were significantly thicker in the leprosy patients as compared to Standard values. All the 8 leprosy patients had one or more nerves which were enlarged (based on the upper limit of normal mean+2SD). Significantly enlarged nerves with a CSA.110 mm2 were observed in 2 nerves ( 2 Ulnar N ). Maximum percentage (50%) of the patients had an ulnar nerve thickened in the range of 3-3.9mm. 25% of the patients had a significant thickening of 5 mm and above. Intra-neural flow suggestive of increased neural vascularity by CD imaging was observed in 4 cases (2 were BL type,1 case was BB type,1case was LL type) . Neural vascularity was observed more frequently in upper limb nerves with Ulnar Nerve being most affected. All the nerves with neural vascularity were associated with lepra reactions.

In Marco Andrey Cpiriani Frade et al,[4] majority of patients had borderline tuberculoid Hansen (31 patients), in current study majority (3) had borderline tuberculoid Hansen Mean age 33.1(12-67) for leprosy patients in Marco Andrey Cipriani Frade et al,[4] Mean age for leprosy patients in current study 33.9. In Suman jain et al,[5] study majority of patients had borderline lepromatous Hansen (10 patients), in current study majority (3) had borderline tuberculoid Hansen. In both studies Neural vascularity most commonly involving upper limb nerves. In Suman jain et al,[5] study Normal echo patterns observed in 50% of the nerves. In the remainder 16.4% nerves showed mild, 29.7% nerves moderate and 3.9% nerves showed severe reduced echo reflectivity. In current study Normal echo patterns observed in 68% of the nerves. In the remainder 13.7% nerves showed mild, 7.5% nerves moderate and 10% nerves showed severe reduced echo reflectivity.

The 10 peripheral nerve sheath tumors in our study comprised 5 schwannomas and 5 neurofibromas. The locations of the tumors were ulnar nerve (n = 6), median nerve (n=1), superficial radial nerve (n=2), lateral cutaneous nerve of thigh(n=1). Regarding echogenicity relative to skeletal muscle, three (80%) of five schwannomas were hypoechoic and one (20%) of five had a target appearance. Of the five neurofibromas, three were predominately hypoechoic and two had a target appearance. No peripheral nerve sheath tumors were classified as completely anechoic or hyperechoic. With regard to internal homogeneity, two (40%) of five schwannomas were homogeneous, and three (60%) had a heterogeneous appearance with cystic areas. Of the five neurofibromas, three were homogeneous and two were heterogeneous. With regard to posterior acoustic enhancement and shadowing, four (80%) of five schwannomas showed posterior acoustic enhancement and one (20%) of five showed posterior acoustic shadowing. Of the five neurofibromas, four were characterized by posterior acoustic


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enhancement, and one had both posterior acoustic shadowing and enhancement.

Continuity with the involved peripheral nerve was shown in all the peripheral nerve sheath tumors examined. All the five neurofibromas and one (20%) of five schwannomas were centrally related to the involved peripheral nerve. Four (80%) of five schwannomas was eccentrically related to the involved peripheral nerve. All five schwannomas and one of four neurofibromas presented as focal masses. Three of four neurofibromas diffusely involved the peripheral nerve. All peripheral nerve sheath tumors underwent color or power Doppler sonography. Of these, two of five schwannomas and two of five neurofibromas showed increased vascularity with prominent arterial flow. In our study total 12 cases were found to have compressive neuropathy. Out of them in majority of the cases median nerve was involved (7cases, 58%), in two cases radial nerve was involved (17%), in two cases posterior interosseous nerve was involved (17%) and ulnar nerve was involved in one case (8%). Majority of patients with entrapment neuropathy were in age group of 30 to 40 years of age. The mean age of patients in the study was 30 yrs. The mean age for male was 24 yrs. The mean age for female was 32 yrs. There were 10 females (83%) and two male patients (16%) in the study. Two patients had bilateral carpal tunnel syndrome. Three patients had right side involvement and two had left side involvement. Majority of patients had symptoms of less than 6 months duration. Most common symptom was pain in the hand followed by numbness in lateral 3 1/2 fingers. Majority of the patients in the study underwent surgical treatment (11 cases).

Accurate detection of median nerve entrapment in patients with a clinical suspicion of carpal tunnel syndrome is essential, especially if surgery is contemplated. MRI and sonography have both been advocated as noninvasive diagnostic techniques for the detection of median nerve entrapment. Both provide direct visualization of the median nerve within and proximal to the flexor retinaculum, enabling morphologic assessment of the median nerve, including nerve swelling, edema, flattening, and bowing of the flexor retinaculum.

A number of authors have reported the accuracy of sonography criteria of median nerve entrapment and several studies have addressed the quantification of the nerve cross- sectional area and its role in diagnosing carpal tunnel syndrome. Review of these studies reveals a number of discrepancies in the accuracy of various sonography criteria in diagnosing carpal tunnel syndrome. Mean cross sectional area of median nerve at the carpel tunnel of patients suffering from carpel tunnel syndrome was 13.9mm2 which showed statistically significant difference compared to standard reference values. All the 7 patients with median nerve involvement manifesting as carpel tunnel syndrome showed central intraneural vascularity. Nerve edema was found in 6cases with median nerve entrapment (85%) while absent in one case (14%). Flattening of median nerve was found in all the cases. Bowing of flexor retinaculum was seen in 5 cases (71%) and absent in 2 cases (28%).

Our findings are supported by the data in the literature, which show an emerging diagnostic role for ultrasound in entrapment neuropathies. Simon et al.[6] reported that changes in the CSA and echogenicity correlate with the severity of the lesion.[7] Yoon et al.[8] and Simon et al.[6] found high-resolution ultrasonography more useful than electrodiagnostic tests for ulnar neuropathy; also, Beekmann et al,[9] showed that the sensitivity of electrodiagnostic tests can be increased from 78% to 98% by adding ultrasonography, while Pardal-Fernandez even proposed substituting ultrasonography for EMG and velocities conduction studies as a first-line examination in selected cases.[10] Cesmebasi et al,[11] also reported on the usefulness of dynamic ultrasound in identification of a palmaris profundus tendon, a feature that, determining a dynamic compression, cannot be shown by MRI.

## CONCLUSION

The use of nerve blood flow as a biomarker in lepra reactions is clinically highly relevant. In addition, USG provides important additional features of nerve pathology in nerve trauma, nerve tumours and the assessment of inflammatory nerve diseases. Clinical examination of enlarged nerves in leprosy patients is subjective and inaccurate, whereas sonography provides an objective measure of nerve damage by showing increased vascularity, distorted echotexture and enlargement. High Frequency with Doppler Ultrasound provides high- resolution, precise anatomical and physiological information of the median nerve in carpal tunnel. In our study ,all the sonographic criteria(presence of nerve edema, nerve swelling, nerve flattening, bowing of the flexor retinaculum, or intraneural hypervascularization shows significant detectability of carpal tunnel syndrome. Our results suggest that, for entrapment neuropathies, ultrasound is a sensitive diagnostic tool which correlates with electrodiagnostic findings: in carpal tunnel syndrome, nerve CSA and nerve hypoechogenicity were always normal in minimal or mild cases and always altered in moderate to extreme cases. Also, the presence of epineurial hyperechogenicity indicated a more advanced degree of severity, and could represent a good indicator of epineurial fibrosis and need for surgical neurolysis.

In cubital tunnel syndrome, ultrasound was even more sensitive, nerve CSA and nerve echogenicity being altered also in mild cases. From a surgical point of view, ultrasound facilitated surgical approach by showing anatomical or dynamic alterations such as a bifid median nerve or nerve dislocation that would have not be identified preoperatively otherwise. If it is true that these alterations would not have altered the surgical plan, it is also true that this thorough


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preoperative evaluation allowed for a better discussion with the patient and for faster and easier surgery, at the expense of only the small amount of extra time required for the preoperative ultrasound evaluation. It allowed not only the identification of an amputation neuroma of larger nerves (i.e. median or ulnar) but also of small terminal branches (common palmar and proper palmar digital nerves) or neuromas-in-continuity, distinguishing interrupted fascicles from those in continuity. Ultrasound facilitated surgical planning in patients with neuromas, foreign bodies, and postfracture complications, allowing for targeted surgery and avoiding wide accesses for exploration because of accurate localization and estimation of nerve damage.

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