e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2023; 15(4); 1038-1045

Original Research Article

Evaluation of Hazards of Ionizing Radiation on Nerve Conduction in Superior Extremity with Duration of Exposure at Tertiary Care Institute: A Comparative Study

Kiran Thorat[1], Manish Goyal[2], Priyanka Bansal[3], Shefali Singhal[4]

[1]Associate Professor, Department of Physiology, SRVS Government Medical College, Shivpuri, Madhya Pradesh

[2]Associate Professor, Department of Physiology, Rajmata Shrimati Devendra Kumari Singh Deo Government Medical College, Ambikapur, Chhattisgarh

[3]Assistant Professor, Department of Pediatrics, SRVS Government Medical College Shivpuri, Madhya Pradesh

[4]Senior Resident, Department of Physiology, Kanti Devi Medical College, Mathura, Uttar Pradesh

Received: 16-01-2023 / Revised: 26-02-2023 / Accepted: 28-03-2023

Corresponding author: Dr Shefali Singhal

Conflict of interest: Nil

Abstract

Introduction: Peripheral neuropathies are unfavorable consequences of radiation treatment. Tissue changes due to Radiation Exposure result in inflammation and fibrosis that affect the peripheral nerve and lead to peripheral neuropathies. Since the introduction of numerous new radiologic procedures, uses of radiation are increasing in modern medicine. Radiation exposure of Radiologic Technologists (RTs) is about two times higher than that of other occupation groups in the fields , such as physicians, dentists, dental hygienists, and nurses.

For better understanding peripheral nerves functioning Nerve Conduction Study (NCS) are most frequently used in neurophysiological laboratories. · we tried to study the effect of chronic radiation exposure on peripheral nerve conduction study parameters in RTs.

Material and Methods: The Present study is a cross-sectional analytic prospective hospital-based study. In present hospital-based study a sum of 60 individuals were selected, of which all of them were Radiologic Technologists (study group/cases), were grouped upon duration of occupational radiation exposure. Group I-RTs with duration of exposure <10 years averaging 6.27 ± 2.05 years. Group II - RTs with duration of occupational radiation exposure 11-25 years averaging 14.44 ± 3.35 years and Group III - RTs with duration of occupational radiation exposure >20 years averaging 23.60±5.21.

The Nerve conduction study parameters were recorded with the help of computerized RMS EMG EP Mark –II, made 2015 machine, Panchkula, Haryana, using conducting jelly and recording electrodes.

Results & Discussion: We found changes in both sensory and motor nerve conduction study parameters in RTs of different duration of occupational exposure. With increase in duration of exposure nerve distal latencies were increased and, Amplitudes (CMAP/SNAP) and NCV were reduced among group I and III. Group II showed variable results.

Nerve Conduction velocity showed a reducing trend with the increasing duration of radiation exposure, this may be due to the reason that Nerve Conduction velocity excludes the individual anthropometric variations.

Conclusion: Conclusion of our study is that ionizing radiations are harmful to all the body tissues including the peripheral nerves. Radiations appear to cause both demyelination and axonal loss.

Keywords: Ionizing radiations, Radiology technologists, Nerve conduction study

Introduction

For better understanding peripheral nerves functioning Nerve Conduction Study (NCS) are most frequently used in neurophysiological laboratories [1]. These studies are basically meant for observing functioning of nerves by generating potentials in nerves or muscular activity supplied by them hence if any abnormality lies with the functioning of nerves it can be easily picked by routine procedures [2]

Motor Nerve Conduction Studies (MNCS) require stimulation of a peripheral nerve while recording from a muscle innervated by the nerve. Sensory Nerve Conduction Studies (SNCS) are performed by stimulating a mixed nerve and recording from a mixed or cutaneous nerve [3].Peripheral neuropathies are unfavorable consequences of radiation treatment. Tissue changes due to Radiation Exposure result in inflammation and fibrosis that affect the peripheral nerve and lead to peripheral neuropathies [4].

At the mercy of radiation foci, radiation quantity and modalities of radiation distribution, the incidence of radiation-induced neuropathies is capricious [5].

Since the introduction of numerous new radiologic procedures, uses of radiation are increasing in modern medicine. Radiation exposure of Radiologic Technologists (RTs) is about two times higher than that of other occupation groups in the fields of diagnostic radiation workers, such as physicians, dentists, dental hygienists, and nurses [6].

RTs are typically exposed to low doses of radiations for longer periods, which have a health risk over many organs and tissues including peripheral nerves. Effects on nerve conduction study due to radiation therapy are well known [7-12]. However, alterations in Nerve conduction study parameters in RTs have not yet been reported properly.

Hence, we tried to study the effect of chronic radiation exposure on peripheral nerve conduction study parameters in RTs. The effects of ionizing radiations may arouse from any quantity of dosing. The interaction of radiation with the DNA of the cells may cause the radiolysis of water inside the cell producing free radicals [13].

Thus, in present study we mainly concentrate on assessing the nerve conduction study parameters within groups of RTs depending upon the duration of exposure to radiations and access its effect on NCS.

Material and Methods

The present study was carried out in the Department of Physiology, at tertiary care institute. Ethical committee approval for the study was obtained from the Institutional Ethical Committee. Present study is a cross-sectional analytic prospective hospital-based study.

In present hospital-based study a sum of 60 individuals were selected, of which all of them were Radiologic Technologists (study group/cases). These subjects were grouped upon duration of occupational radiation exposure. Group I was having radiology technologists with duration of exposure <10 years averaging 6.27 ± 2.05 years. Group II was having RTs with duration of occupational radiation exposure 11-25 years averaging 14.44 ± 3.35 years and Group III was having RTs with duration of occupational radiation exposure >20 years averaging 23.60±5.21.

Males and females of 30-60 years of age groups were considered for the study. The study group (n=60) included Radiologic Technologists (RTs), who had a history of occupational exposure to ionizing radiations. The participants of the study group were selected on the basis of duration of exposure to Ionizing Radiation for more than 3 years. The RTs from the Radiology, Radiotherapy, orthopedics and cardiology departments.

Written and informed consent was obtained from each participant over a consent form. Initially detailed history was taken from each participant of the study as per standard operating procedures of the study. All individuals were screened, and inclusion criteria were young adults with no history of systemic or neuromuscular diseases, normal neurological examination and normal laboratory findings including blood sugar level, electrolytes and renal function was considered.

A simple neurological examination was performed including muscle power testing, muscle stretch reflexes and sensation including superficial and deep sensory testing. The procedure for Nerve Conduction test was explained to the subjects. The Nerve conduction study parameters were recorded with the help of computerized RMS EMG EP Mark –II, made 2015 machine, Panchkula, Haryana, using conducting jelly and recording electrodes.

The stimulus was given with the help of stimulator using supra-maximal stimulus. Motor Nerve conduction study (MNCS) parameters were recorded in Median, Ulnar and Radial nerves on both right and left Upper extremities. Sensory Nerve conduction study parameters were recorded in Median, Ulnar and Radial nerve on both right and left sides. A standardized technique was used to obtain and record action potentials for motor and sensory studies [8, 9].

Inclusion Criteria

1. **Study group:** Radiologic Technologists who were regularly exposed to ionizing radiations (>3years).

Exclusion Criteria

1. Subjects with any pre-existing neurological disorders and with history of smoking, tobacco and alcohol consumption.
2. Subjects with any other systemic diseases and/or conditions affecting nerve conduction study parameters like
3. Hypertension, diabetes, hyper/ hypothyroidism.
4. Metabolic disorders.
5. Peripheral nerve injuries and Radiculopathies.
6. Cervical spondylosis.
7. History of medication affecting neuromuscular system.
8. Compression neuropathies.

Statistical analysis was done by descriptive and inferential statistics to compare between cases and controls, and one way ANOVA test for in-house comparison among cases to assess the effect of duration of radiation exposure. $P < 0.05$ was considered as statistically significant. Commonly measured parameters of CMAP and SNAP include distal latency, amplitude, conduction velocity and duration [10].

Results

Table 1: Vital Data of different groups of Cases

Parameters	**Group I* (N=22) mean ±SD**	**Group II** (N=18) mean ±SD**	**Group III*** (N=20) mean ±SD**	**p value#**
Age (Years)	32.55±2.58	43.67±4.77	54.70±3.62	**0.001**
Height (cms)	164.10±7.13	165.30±8.00	166.40±4.55	0.268
Weight (kgs)	69.94±9.07	68.48±7.68	71.32±9.46	0.746
BMI (Kg/m^2)	26.04±3.87	25.06±2.30	25.73±3.07	0.341
Duration of Radiation exposure (Years)	6.27±2.05	14.44±3.35	23.60±5.21	**0.025**

N= Number of participants

* Duration of occupational radiation exposure <10 years
** Duration of occupational radiation exposure 11-25 years
*** Duration of occupational radiation exposure >25 years
# p <0.05 is considered as significant

This Table shows comparison of mean age, height, weight, BMI and duration of occupational radiation exposure between different groups of cases (Radiologic technologists).

Table 2: Comparison of motor distal latencies in Cases of different duration of exposure

Motor Nerve Distal latencies (ms)	Group I (n=22) mean ±SD	Group II (n=18) mean ±SD	Group III(n=20) mean ±SD	p value#
Median Nerve	3.06 ± 0.5	2.84 ± 0.28	3.14 ± 0.55	>0.05
Ulnar Nerve	2.52 ± 0.64	2.37 ± 0.36	2.54 ± 0.66	>0.05
Radial Nerve	1.55 ± 0.39	2.00 ± 1.18	1.94 ± 0.58	>0.05

# p <0.05 is considered as significant

This Table shows comparison of motor nerve distal latencies between groups of cases. No significant changes were observed in all nerves in groups of cases.

Table 3: Comparison of motor nerve CMAP amplitude in Cases of different duration of exposure

CMAP Amplitude(mV)	Group I (n=22) mean ±SD	Group II (n=18) mean ±SD	Group III (n=20) mean ±SD	p value#
Median Nerve	12.55 ± 3.5	12.41 ± 3.88	9.85 ± 3.48	**<0.05**
Ulnar Nerve	8.86 ± 2.38	8.63 ± 1.60	8.26 ± 2.61	>0.05
Radial Nerve	4.40 ± 2.23	3.50 ± 1.85	3.50 ± 1.56	>0.05

# p <0.05 is considered as significant

This Table shows the comparison of CMAP amplitudes in motor nerves in different groups of cases. Significant (p <0.05) reduction was observed in Median and Tibial nerves while no significant changes were observed in Ulnar, Radial and Common peroneal nerves.

Table 4: Comparison of motor nerve conduction velocities in Cases of different duration of exposure

Motor Conduction Velocity (m/s)	Group I (n=22) mean ±SD	Group II (n=18) mean ±SD	Group III (n=20) mean ±SD	p value#
Median Nerve	55.29 ± 7.11	53.16 ± 6.48	48.50 ± 8.22	**<0.05**
Ulnar Nerve	60.13 ± 6.42	56.66 ± 6.40	54.16 ± 6.90	**<0.05**
Radial Nerve	56.24 ± 9.20	52.88 ± 8.78	50.43 ± 7.74	>0.05

# p <0.05 is considered as significant

This Table shows the comparison of conduction velocities in motor nerves in different groups of cases. Significant (p <0.05) reduction was observed in Median and Ulnar nerves while no significant changes were observed in Radial, Common peroneal and Tibial nerves.

Table 5: Comparison of sensory latencies in Cases of different duration of exposure

Sensory latencies (ms)	Group I (n=22) mean ±SD	Group II (n=18) mean ±SD	Group III (n=20) mean ±SD	p value#
Median Nerve	2.55 ± 0.37	2.64 ± 0.28	2.95 ± 0.51	**<0.05**
Ulnar Nerve	2.15 ± 0.25	2.43 ± 0.39	2.31 ± 0.31	**<0.05**
Radial Nerve	1.69 ± 0.28	1.88 ± 0.34	2.06 ± 0.31	**<0.05**

# p <0.05 is considered as significant

This Table shows the comparison of latencies in sensory nerves in different groups of cases. There was significant ($p < 0.05$) increase in latency was observed in all nerves.

Table 6: Comparison of SNAP amplitude in Cases of different duration of exposure

SNAP Amplitude (µV)	Group I (n=22) mean ±SD	Group II (n=18) mean ±SD	Group III (n=20) mean ±SD	p value#
Median Nerve	37.64 ± 16.04	28.07 ± 15.82	24.75 ± 7.13	**<0.05**
Ulnar Nerve	25.43 ± 14.54	15.34 ± 10.23	18.96 ± 8.90	**<0.05**
Radial Nerve	28.33 ± 8.43	22.81 ± 10.59	20.05 ± 6.61	**<0.05**

# $p < 0.05$ is considered as significant

This Table shows the comparison of SNAP amplitude in sensory nerves in different groups of cases. Significant ($p < 0.05$) reduction was observed in all nerves.

Table 7: Comparison of sensory conduction velocities in Cases of different duration of exposure

Sensory Conduction Velocity (m/s)	Group I (n=22) mean ±SD	Group II (n=18) mean ±SD	Group III (n=20) mean ±SD	p value#
Median Nerve	55.29 ± 7.11	53.16 ± 6.48	48.50 ± 8.82	**<0.05**
Ulnar Nerve	55.66 ± 5.58	48.31 ± 6.50	50.53 ± 3.88	**<0.05**
Radial Nerve	63.25 ± 8.24	52.93 ± 5.99	49.68 ± 7.69	**<0.05**

# $p < 0.05$ is considered as significant

This Table shows the comparison of conduction velocity in sensory nerves in different groups of cases. Significant ($p < 0.05$) reduction was observed in all nerves.

Discussion

The present study was conducted to assess the effects of chronic low dose ionizing radiation exposure over nerve conduction study parameters. In this study we included 60 radiologic technologists of 30- 60 years age group (Mean age 43.27 ± 10.1 years) all were with age and sex matched 60 subjects of 30-60 years age group (mean age 42.17± 8.46 years).

Cases were further divided into three groups on the basis of duration of radiation exposure as follows:

Group I: duration of occupational radiation exposure< 10 years (n1=22) Group II: duration of occu0pational radiation exposure 11-25 years (n2=18), Group III: duration of occupational radiation exposure>25years (n3=20). The mean age of group I, group II and group III were 32.55±2.58, 43.67±4.77 and 54.70±3.62 years respectively. Mean duration of occupational radiation exposure in group I, group II and group III subjects were 6.27 ±2.05, 14.44±3.35 and 23.60±5.21years respectively. There was no significant difference in height, weight and BMI among the three groups of cases.

Assessment of motor nerve conduction study parameters in the three groups of radiologic technologists' comparison of motor nerve distal latencies on analyzing via one-way ANOVA the distal motor distal latencies among the three groups viz groups I, group II and group III were not significantly different in any of the examined motor nerves.

Median nerve (group I- 3.06±0.5, group II- 2.84±0.28, and group III- 3.14±0.55 ms; $p > 0.05$), Ulnar nerve (group I- 2.52±0.64, group II- 2.37±0.36, and group III- 2.54±0.66 ms; $p > 0.05$), Radial nerve (group I- 1.55±0.39, group II- 2.00±1.18, and group III- 1.94±0.58 ms; $p > 0.05$) did not showed any clear pattern of change in distal latency among the three groups of cases.

Comparison of CMAP amplitude the CMAP amplitude among the three groups viz groups I, group II and group III were significantly different in Median and Tibial nerves while no significant difference was observed in Ulnar and Radial nerves.

Median nerve (group I- 12.55±3.5, group II- 12.74±3.88, and group III- 9.85±3.48 mV; $p <0.05$), Ulnar nerve (group I- 8.26±2.61, group II- 8.86±2.38, and group III- , 8.63±1.60 mV; $p > 0.05$), Radial nerve (group I- 4.40±2.23, group II- 3.50±1.85, and group III- 3.50±1.56 mV; $p > 0.05$), showed specific pattern of reduction in CMAP amplitude, where the values in group III were lower compared to group I. However, Group II did not match the trend.

The NCV among the three groups viz groups I, group II and group III were significantly different in Median and Ulnar nerves while no significant difference was observed in Radial nerve.

Median nerve (group I- 55.29±7.11, group II- 53.16± 6.48 and group III- 48.50±8.22 m/s; $p < 0.05$), Ulnar nerve (group I- 60.13±6.42, group II- 56.66±6.40 and group III- 54.16±6.90 m/s; $p < 0.05$), Radial nerve (group I- 56.24±9.20, group II- 52.88±8.78 and group III- 50.43±7.74 m/s; $p > 0.05$) showed specific pattern of reduction in nerve conduction velocity, where the values in group III were lower compared to group I. Here, group II also matched the trend where conduction velocity was lower in group II compare to group I and was lowest in group III.

The three groups of radiologic technologists Comparison of sensory nerve latencies. The sensory nerve latencies among the three groups viz groups I, group II and group III were found significantly different in all the examined sensory nerves. Median nerve (group I- 2.55±0.37, group II- 2.64±0.28, and group III- 2.95± 0.51 ms; $p < 0.05$), Ulnar nerve (group I- 2.15±0.25, group II- 2.43±0.39, and group III- 2.31±0.31 ms; $p < 0.05$) and Radial nerve (group I- 1.69±0.28, group II- 1.88±0.34, and group III- 2.06±0.31 ms; $p < 0.05$) showed specific pattern of increase in latency, where the values in group III were higher compared to group I. Where, Group II also matched the trend in median and radial nerves.

The SNAP amplitudes among the three groups viz groups I, group II and group III were found significantly different in all the examined sensory nerves. Median nerve (group I- 37.64±16.04, group II- 28.07±15.82, and group III- 24.75±7.13 μV; $p <0.05$), Ulnar nerve (group I- 25.43±14.54, group II- 15.34±10.23, and group III- 18.96±8.90 μV; $p < 0.05$) and Radial nerve (group I- 28.33±8.43, group II- 22.81±10.59, and group III- 20.05±6.61 μV; $p < 0.05$) showed specific pattern of reduction in SNAP amplitude, where the values in group III were lower compared to group I. Where, Group II also matched the trend in median and radial nerves.

The sensory nerve conduction velocity among the three groups viz groups I, group II and group III were found significantly different in all the examined sensory nerves.

Median nerve (group I- 55.29±7.11, group II- 53.16±6.48 and group III- 48.50±8.82 m/s; $p <0.05$), Ulnar nerve (group I- 55.66±5.58, group II- 48.31±6.50 and group III- 50.53±3.88 m/s; $p < 0.05$) and Radial nerve (group I- 63.25±8.24, group II- 52.93±5.99 and group III- 49.68±7.69 m/s; $p < 0.05$) showed specific pattern of reduction in NCV, where the values in group III were lower compared to group I. Where, Group II also matched the trend in median and radial nerves.

In accordance with Akleyev who has mentioned the effect of duration of low-intensive radiation exposure on nervous tissues. He mentioned that under the conditions of radiation exposure lasting from 3 to7 years, micro-organic damages to the neural tissue was manifested by changes in the cranio-cerebral nerve functions, disorders of the motor, reflex and sensory functions [14].

Akleyev AV stated in his publication this micro-organic damage to the neural tissues is laid by diffuse micro-necrotic changes in myelin membranes of the nerves, and dystrophic changes in the ganglia followed by diffused glial proliferation [15].

We also found changes in both sensory and motor nerve conduction study parameters in RTs of different duration of occupational exposure. With increase in duration of exposure nerve distal latencies were increased and, Amplitudes (CMAP/SNAP) and NCV were reduced among group I and III. Group II showed variable results.

After 10 years of duration of radiation exposure the results were not in one direction. Most of the parameters in all nerves are worse in group III compare to group II but some parameters are better in group III than group II. This may be an incidental finding.

As explained in earlier studies by Stoll *et al*. and Westling *et al*. symptoms of high dose radiation damage in sensory nerves appear earlier than motor [9,10], We also found higher degree of changes in sensory nerves compared to motor nerves with increase in duration of occupational radiation exposure.

Nerve Conduction velocity showed a reducing trend with the increasing duration of radiation exposure, this may be due to the reason that Nerve Conduction velocity excludes the individual anthropometric variations. In present study we do not observe a clear trend among the three groups in CMAP amplitude and Latencies, which may be due to the fact that CMAP amplitude depends on individual muscle mass and latencies depend on person's anthropometric data. Significant results were not observed in most of the data on duration of radiation exposure because of less number subjects in each group.

Conclusion

Conclusion of our study is that ionizing radiations are harmful to all the body tissues including the peripheral nerves. Radiations appear to cause both demyelination and axonal loss. As per reports no research work was done showing effect of occupational radiation exposure on NCS, so further detailed study is needed to understand the pathophysiology behind these changes. An adequately powered study design which uses the objective measurements of the occupational radiation doses and the detailed NCS and assessment of HPs are expected to provide a better insight to the suggested relationship.

We also found reduced CMAP amplitude (significant in Median and Tibial nerves) in radiologic technologists. Although there was a trend of increasing motor distal latencies in Tibial nerve but there was no significant change among the groups to delineate effect of radiation exposure.

As Nerve Conduction velocity of all the motor and sensory nerves was found significantly reduced among cases compare to controls and it also showed a reducing trend with the increasing duration of radiation exposure it can be considered as a most reliable parameter for accessing the risk of occupational radiation exposure on peripheral nerves. This may be due to the reason that Nerve Conduction velocity excludes the individual anthropometric variations.

We observed that, all the parameters in sensory nerves were affected among cases while that was not so with the motor nerves, which shows that the sensory nerves were more affected than motor nerves.

So, we concluded that the chronic low dose exposure of ionizing radiation causes sub-clinical neuronal changes affecting both sensory and motor nerves. Hence this study could be a stepping stone toward accessing effects of radiation in health care workers.

References

1. Jain A. K., Manual of Practical Physiology for MBBS, 5th Edition, 2018: 287.
2. Ali K, Singhal S, Rizvi SAA, Muzammil M. Comparison of NCV of Right and Left Limb in Right-handed Male Subjects. Ann Int Med Den Res. 2016;2(4):228-31.
3. Valls-Sole J, Leote J, Pereira P. Antidromic vs orthodromic sensory median nerve conduction studies. Clin Neurophysiol Pract. 2016 Apr 7;1:18-25.
4. Manne R, Thakkar P, Zheng J. Radiation-Induced Obturator Nerve Injury in Cervical Cancer. J Rehabil Med Clin Commun. 2021 Jan 18;4:1000043.
5. Vasic L. Radiation-induced peripheral neuropathies: Etiopathogenesis, risk factors, differential diagnostics, symptoms and treatment. Arch Oncol. 2007;15(3–4):81–4.
6. De Carolis P, Montagna P, Cipulli M, Baldrati A, D'Alessandro R, Sacquegna T. Isolated lower motoneuron involvement following radiotherapy. J Neurol Neurosurg Psychiatry. 1986 Jun;49(6):718– 9.
7. Brennan MJ. Breast cancer recurrence in a patient with a previous history of radiation injury of the brachial plexus: a case report. Arch Phys Med Rehabil. 1995 Oct;76(10):974–6.
8. Soto O. Radiation-induced conduction block: Resolution following anticoagulant therapy. Muscle Nerve. 2005; 31(5):642–5.
9. Stoll BA, Andrews JT. Radiation-induced Peripheral Neuropathy.Br Med J. 1966 Apr 2;1(5491):834–7.
10. Westling P, Svensson H, Hele P. Cervical plexus lesions following post-operative radiation therapy of mammary carcinoma. Acta Radiol Ther Phys Biol. 1972 Jun;11(3):209–16.
11. Feistner H, Weissenborn K, Münte TF, Heinze HJ, Malin JP. Post- irradiation lesions of the caudal roots. Acta Neurol Scand. 1989 Oct;80(4):277–81.
12. Cember H, Johnson TE, Alaei P. Introduction to Health Physics: Fourth Edition. Med Phys. 2008;35(12):5959.
13. Ahmed RG. Damage pattern as function of various types of radiations. Med J Islam World Acad Sci. 2005;15(4):135-47.
14. Akleyev AV. Chronic radiation syndrome among residents of the Techa riverside villages. Radiat Prot Dosimetry. 2012 Oct 1;151(4):689–95.
15. Akleyev AV. Normal tissue reactions to chronic radiation exposure in man. Radiat Prot Dosimetry. 2016 Sep;171(1):107–16.