Original Article

The Association Between Lipid Lowering Agents and Development of Peripheral Neuropathy

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Abstract

Background: Statin drugs are widely recommended to lower lipid levels in the blood and reduce the risk of cardiovascular disease and mortality, long-term treatment can result in side effects such as neuromuscular symptoms and peripheral neuropathy, which are now one of the main reasons for discontinuing statin therapy. **Objectives:** To estimate the possible association between the use of statin and the occurrence of peripheral neuropathy and assessed by electrodiagnostic study. **Materials and Methods:** This case–control study was conducted in neurophysiological unit in collaboration with the cardiology unit in Shaheed Al Mehrab Catheterization Center in Merjan Medical City in Al-Hilla City in Iraq. A sample of 50 patients consisted of 40 males and 10 females, the age of distribution of the study group ranged from 30 to 65 years with daily consumption of statin for more than 6 months. The control group comprised 50 patients, including 40 males and 10 females, who were relatives, friends, medical staff, and relatives of patients. The patients, aged between 30 and 65 years, had never complained about any signs of peripheral neuropathy. Each patient had the same neurophysiological tests for the sensory and motor wave (amplitude, latency, and nerve conduction velocity) of the peripheral nerves (median, ulnar, sural, tibial, and peroneal). **Results:** The result of this study shows a statistically significant difference between the ages. In this study, cases suffered from peripheral neuropathy were only 14 (28%) compared to 36 (72%) cases without peripheral neuropathy. The patients on statins showed the amplitudes were significantly decreased in median (motor and sensory) with P value < 0.05, ulnar (only sensory), P value < 0.001, sural nerve, P value < 0.003, and tibial nerves, P value < 0.001. Whereas latencies were significantly prolonged in median (motor only), P value < 0.001 and ulnar (motor and sensory), P value < 0.05, sural, P value < 0.001 and tibial nerves, P value < 0.022. Regarding the F-wave, we found that it was prolonged in median, ulnar, peroneal, and tibial nerves, P value < 0.001. **Conclusion:** Statin consumption can cause changes in the peripheral motor and sensory nerves and increase the risk of peripheral neuropathy with statin exposure. However, awareness of the side effects would lead to better treatment.

Keywords: Nerve conduction, peripheral neuropathy, statin

Introduction

Statins are hydroxymethylglutaryl-coenzyme reductase inhibitors reduce serum cholesterol and low-density lipoprotein levels while increasing high-density lipoprotein levels.[1] Clinical trial data is beginning to show that statins can effectively treat dyslipidemia by reducing LDL-C, the main atherogenic lipoprotein.[2]

Statins provide other advantages in addition to reducing cholesterol, statins also have antioxidant, anti-inflammatory, antiproliferative, cell cycle regulation, apoptosis, and immunomodulatory properties which are known as "pleiotropic effects."[3] Although statin drugs are widely recommended to reduce cardiovascular disease and mortality,[4] long-term treatment can result in side effects such neuromuscular symptoms and peripheral neuropathy, which are now one of the main reasons for discontinuing statin therapy.[5]

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The peripheral neuropathy is manifested by tingling, numbness, pain, burning, weakness, and unsteady walking, these symptoms are often caused by long-term use of statins.[6] Drugs induce peripheral neuropathy is still a diagnosis of exclusion, based mostly on the patient's history[7] and confirmed by nerve conduction study which is the most accurate, sensitive, and informative method of measuring peripheral nerve functioning. Additionally, these tests are considered a supplementary component of the clinical neurological examination and have long been recognized as the gold standard for the diagnosis of all neuropathies.[8]

Materials and Methods

Patients and settings

A case–control study was conducted in neurophysiological unit in collaboration with the cardiology unit in Shaheed Al Mehrab Catheterization Center in Merjan Medical City in Al-Hilla City from the first of August, 2022 until the first of January, 2023.

A sample of 50 patients, the study group consisted of 40 males and 10 females, the age of distribution of the study group ranged from 30 to 65 years. A sample of 50 patients consisted of 40 males and 10 females, the age of distribution of the study group ranged from 30 to 65 years with daily consumption of statin more than 6 months. The control group comprised 50 patients, including 40 males and 10 females, who were relatives, friends, medical staff, and relatives of patients. The participants, aged between 30 and 65 years, had never complained about any signs of peripheral neuropathy A full history was taken from each patient including personal data like name, age, sex, history of presenting illness, and any history of drugs, type of drugs and doses and history of other disease. The cases were selected according to the inclusion and exclusion criteria listed.

Inclusion criteria

- Age of the patients between 30 and 65 years.
- Daily consumption of statins at least 6 months.

Exclusion criteria

- Diabetes mellitus, chronic renal failure, thyroid disease.
- Hereditary neuropathy, active radiculopathies, vasculitis, metabolic disease.
- Fracture in lower and upper limbs, rheumatic disease, B12 deficiency, space-occupying lesions in upper and lower limbs.
- Digestive diseases such as celiac and inflammatory bowel syndrome.
- Drugs that cause peripheral neuropathy such as anticonvulsants, phenytoin, and chemotherapy.

Procedure

After clinical examination, electrodiagnostic tests were performed by a neurophysiologist. The study was done using Nihon Kohden Machine (Japan), and the stimulus intensity was adjusted manually. The device featured an audio amplifier. The body's temperature must be kept above 33°C in the legs and 34°C in the arms. Skin impedance is decreased by properly preparing the recording and stimulating locations. Callous skin requires little exfoliation, the impedance between the electrodes can be reduced by using a cream or solvent with high conductivity to the skin. Electrical normal sensory nerves need a current in the range of 5–30 mA to provide supramaximal stimulation for sensory research. Motor studies are performed by electrical stimulation of a nerve and recording the compound muscle action potential (CMAP) from surface electrodes overlying a muscle supplied by that nerve which is the summated electrical activity of the muscle fibers that are in the region of the recording electrode. Multiple parameters were recorded for each nerve at each stimulation site, including distal latency, conduction velocity, waveform amplitude, duration, and shape.[9] The diagnostic criteria of neuropathic disorders:

- Axonopathy: Decrease in the amplitude with normal or mild decrease in conduction velocity but never below 75% of the lower limit of normal and normal or mild prolongation in distal latency but never above 130% of the upper limit of normal.
- Polyneuropathy: More than two nerves symmetrically and bilaterally affect.
- Mononeuritis multiplex: More than two nerves (affecting both sensory and motor fibers of the same nerve but asymmetrically.
- Myelinopathy: Marked decrease of conduction velocity below 75% of the lower limit of normal with marked prolongation in distal latency of more than 130% of the upper limit of normal and normal or mild decline in the amplitude.[10]

Statistical analysis

All statistical analyses were performed using SPSS software (version 23). For continuous data use *t* test and represent mean ± SD, for categorical data use Chi square test and represent numbers and percentages. The Binary logistic regression analysis for patients with peripheral neuropathy against patients without neuropathy. P value < 0.05 was considered significant.

Ethical approval

Ethical approval for this project was granted by the Ethics Committee at the University of Babylon, College of Medicine, Iraq under reference number 3-1 on

June 30, 2022. Verbal consent was obtained from the participants.

Results

Type and duration of statin in studied patients

Out of the 50 users of statin included in this study, atorvastatin was used in 62.0% of the cases. The median duration of statin usage was 12 months as shown in Table 1.

Nerve conduction study of studied groups

Patients on statins showed the amplitudes were significantly decreased in median (motor and sensory) with *P* value < 0.05, ulnar (only sensory), *P* value < 0.001, sural nerve, *P* value < 0.003, and tibial nerves, *P* value < 0.001. While latencies were significantly longer in median (motor only), *P* value < 0.001 and ulnar (motor and sensory), *P* value < 0.05, sural, *P* value < 0.001 and tibial nerves, *P* value < 0.022. In addition, the conduction velocities were significantly lower in median (sensory only), *P* value < 0.001, ulnar (motor only), *P* value < 0.002, peroneal, *P* value < 0.004 and tibial nerves, *P* value < 0.001 as shown in Tables 2 –12

Table 1: Type and duration of statin in studied patients

Characteristic		Cases, *N* = 50
Type of statin used	Atorvastatins	31 (62.0%)
	Rosuvastatins	19 (38.0%)
Duration of treatment (months)		12.0 (12.0–27.0)
Duration groups	1–2 years	30 (60.0%)
	2–4 years	4 (8%)
	4–6 years	6 (12%)
	6–8 years	2 (4%)
	8–10 years	5 (10%)
	>10 years	3 (6%)

Median nerve conduction study

Table 2: Motor study of the median nerve in studied groups

Motor study of median nerve	Cases, *N* = 50	Control, *N* = 50	*P* value
Amplitude (mv)	9.5 ± 2.2	10.8 ± 2.3	0.005**
Latency (ms)	3.5 ± 0.5	3.0 ± 0.4	<0.001**
Conduction velocity (m/s)	56.1 ± 5.5	71.0 ± 7.1	0.2

**Mean significant

Table 3: Sensory study of the median nerve in studied groups

Sensory study of median nerve	Cases	Control	*P* value
Amplitude (μv)	34.7 ± 13.0	43.3 ± 15.0	0.003**
Latency (ms)	3.9 ± 1.1	2.5 ± 0.4	0.2
Conduction velocity (m/s)	50.5 ± 7.5	57.9 ± 6.9	<0.001**

**Mean significant

Ulnar nerve conduction study

Table 4: Motor study of the ulnar nerve in studied groups

Motor study of ulnar nerve	Cases, *N* = 50	Control, *N* = 50	*P* value
Amplitude (mv)	8.7 ± 1.9	9.2 ± 1.8	0.12
Latency (ms)	3.1 ± 1.2	2.5 ± 0.6	<0.001**
Conduction velocity (m/s)	58.8 ± 5.8	62.7 ± 5.9	0.002**
Ulnar F-wave	28.1 ± 3.7	25.2 ± 1.9	<0.001**

**Mean highly significant

Table 5: Sensory study of the ulnar nerve in studied groups

Sensory study of ulnar nerve	Cases, *N* = 50	Control, *N* = 50	*P* value
Amplitude (μv)	31.7 ± 14.7	42.2 ± 14.7	<0.001**
Latency (ms)	2.4 ± 0.5	2.1 ± 0.3	<0.001**
Conduction velocity (m/s)	51.7 ± 11.3	66.3 ± 64.9	0.12

**Mean highly significant

Sural nerve conduction study

Table 6: Nerve conduction study of the sural nerve in studied groups

Sensory study of sural nerves	Cases, *N* = 50[1]	Control, *N* = 50[1]	*P* value[2]
Amplitude (μv)	12.9 ± 6.1	16.1 ± 4.3	0.003**
Latency (ms)	2.7 ± 0.5	2.3 ± 0.3	<0.001**
Conduction velocity (m/s)	51.0 ± 10.7	53.1 ± 6.1	0.3

**Mean highly significant

Peroneal nerve conduction study

Table 7: Motor conduction study of the peroneal nerve

Motor study of the peroneal nerve	Cases, *N* = 50	Control, *N* = 50	*P* value
Amplitude (mv)	5.1 ± 6.0	5.2 ± 1.1	0.9
Latency (ms)	3.9 ± 0.9	3.5 ± 1.3	0.10
Conduction velocity (m/s)	47.9 ± 5.6	51.2 ± 5.4	0.004**
F-wave	49.3 ± 3.4	46.4 ± 3.1	<0.001**

**Mean highly significant

Nerve conduction study of tibial nerve

Table 8: Nerve conduction study of the tibial nerve in studied groups

Motor study of tibial nerve	Cases, *N* = 50[1] (Mean ± SD)	Control, *N* = 50	*P* value
Amplitude (mv)	10.0 ± 4.2	12.8 ± 3.4	<0.001*
Latency (ms)	4.3 ± 1.9	3.5 ± 1.4	0.022*
Conduction velocity (m/s)	45.7 ± 4.4	54.1 ± 5.3	<0.001**
F-wave	50.0 ± 3.9	47.6 ± 2.5	<0.001*

*Mean significant

**Mean highly significant

The sensory nerve conduction study

Table 9: Sensory study of the median nerve in studied groups

Sensory study of median nerve	Cases	Control	*P* value
Amplitude (μv)	34.7±13.0	43.3±15.0	0.003**
Latency (ms)	3.9±1.1	2.5±0.4	0.2
Conduction velocity (m/s)	50.5±7.5	57.9±6.9	<0.001**

**Mean significant

Table 10: Sensory study of the ulnar nerve in studied groups

Sensory study of ulnar nerve	Cases, *N* = 50	Control, *N* = 50	*P* value
Amplitude (μv)	31.7±14.7	42.2±14.7	<0.001**
Latency (ms)	2.4±0.5	2.1±0.3	<0.001**
Conduction velocity (m/s)	51.7±11.3	66.3±64.9	0.12

**Mean highly significant

Table 11: Nerve conduction study of the sural nerve in studied groups

Sensory study of sural nerves	Cases, *N* = 50[1]	Control, *N* = 50[1]	*P* value[2]
Amplitude (μv)	12.9±6.1	16.1±4.3	0.003**
Latency (ms)	2.7±0.5	2.3±0.3	<0.001**
Conduction velocity (m/s)	51.0±10.7	53.1±6.1	0.3

**Highly significant

Table 12: Age and sex difference in patients with and without peripheral neuropathy

Characteristics	Without PN, *N* = 36	With PN, *N* = 14	*P* value
Age, years	49.4±9.8	55.5±9.0	**0.048****
30–40	10 (83.3%)	2 (16.7%)	
40–50	6 (75%)	2 (25%)	0.16
50–60	18 (78.3%)	5 (22.7%)	
>60	2 (28.5%)	5 (71.5%)	
Sex			
Male	28 (70%)	12 (30%)	0.7
Female	8 (80%)	2 (20%)	

The mean age of the patients was (49.4±9.8 vs. 55.5±9.0) for those without peripheral neuropathy and with peripheral neuropathy respectively, with *P*-value = 0.048. Aside from age, no statistical difference was observed and shown in bold

**Mean highly significant

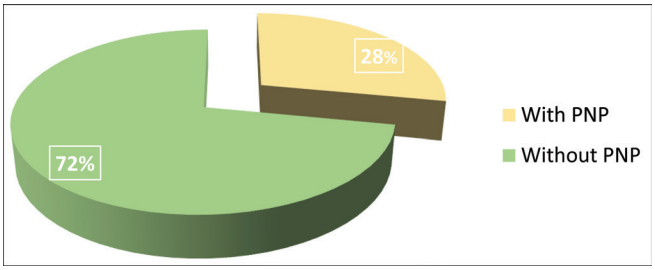

Figure 1: Presence and absence of peripheral neuropathy in patients on statins

Table 13: The effect of statin type and incidence of peripheral neuropathy

Type of statins	Without PN, *N* = 36	With PN, *N* = 14	*P* value
Atorvastatin	19 (61.2%)	12 (38.8%)	0.05**
Rosuvastatin	17 (89.4%)	2 (10.6%)	

**Mean significant

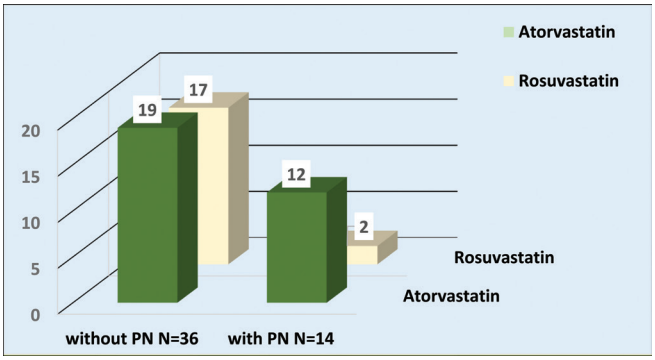

Figure 2: The effect of statin type and incidence of peripheral neuropathy

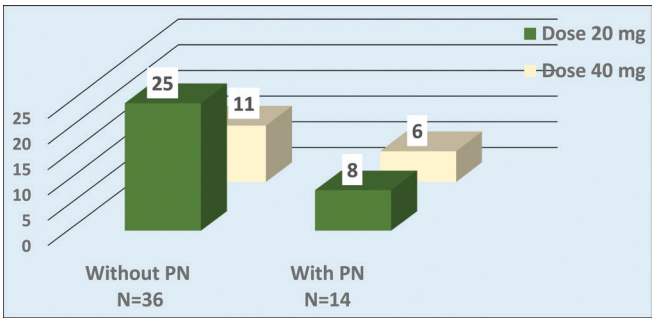

Figure 3: The effect of statin dose and incidence of peripheral neuropathy

Presence and absence of peripheral neuropathy in patients on statins

Regarding the presence or absence of peripheral neuropathy, data from cases only was considered in Table 3. Cases suffered from peripheral neuropathy were only 14 (28%) compared to 36 (72%) cases without peripheral neuropathy as shown in Figure 1.

Age and sex differences in patients with and without peripheral neuropathy

The mean age of the patients was 49.4±9.8 vs. 55.5±9.0 for those without peripheral neuropathy and with peripheral neuropathy respectively, with (*P* value = 0.048). No statistical difference was observed between the presence of neuropathy and sex.

The effect of statin type and incidence of peripheral neuropathy

Table 13 and Figure 2 show that statistically significant differences regarding the use of atorvastatin with *P* value = 0.05.

The effect of statin dose and incidence of peripheral neuropathy

The atorvastatin and rosuvastatin groups were subdivided based on doses of 20 mg and 40 mg. Figure 3 shows that statistically significant differences regarding use of atorvastatin with P value = 0.05.

Discussion

Statins have long been suspected to cause some sort of peripheral neuropathies, however, there are contradicting reports across the world and there is still no clear-cut evidence that statins directly or indirectly cause such disorders, so the current study objective was to investigate the effect of statins on the nerve conduction on five peripheral nerves and look for confounding factors that might affect the results. We studied the effects of the most regularly used statins, atorvastatin and rosuvastatin and compared the incidence of statin use to that of non-drug-taking healthy controls, and investigated the impact of type of statin, dose, and the development of peripheral neuropathy.

In the current study, statin consumption can cause changes in the peripheral motor and sensory nerves. The amplitudes were significantly decreased in the median (motor and sensory), ulnar (only sensory), sural nerves, and tibial nerves. Whereas latencies were highly significant prolonged in median (motor only), and ulnar (motor and sensory), sural, and tibial nerves. In addition, the conduction velocities were significantly lower in the median (sensory only), ulnar (motor only), sural, peroneal, and tibial nerves.

Median nerve conduction study

In the current study, patients on statins showed the amplitudes were significantly decreased in motor and sensory fibers of median nerve, whereas latency was significantly longer in motor fibers of this nerve, and conduction velocity was significantly faster in sensory fibers, in addition to prolonged F-wave. These results were comparable to results of Özdemir *et al*.,[6] who reported that latency of motor median was longer in patients taking statins, and conductions velocity was lower in motor median, however their results were not in agreement with the current study results regarding amplitude, as they reported that cases had significantly lower amplitude in median nerve[6] Another study done by Emad *et al*.,[11] in Iran reported no significant effects of statins on median nerve conduction parameters.

Ulnar nerve conduction study

In the current study, NCS of the ulnar nerve showed lower parameters in patients on statins, and even if some of them did not show statistical significance, it might become significant with time. Özdemir *et al*.[6] reported that all ulnar-NCS parameters were lower in patients on statins, and the difference was significant in motor conduction velocity, sensory latency, and conduction velocity. Emad *et al*.[11] reported slightly lower values of ulnar-NCS, however, none showed a significant difference.

Sural nerve conduction study

In the current study, sural nerve showed a significant reduction in amplitude and prolonged latency in cases in comparison to controls. These results were comparable to results of Özdemir *et al.*,[6] who reported that conduction velocities were lower in sural nerve In addition, Emad *et al.*[11] reported that sural nerve amplitude was significantly lower in patients on statins.

Peroneal and tibial nerve conduction study

Patients on statins showed lower NCS parameters in both nerves, for peroneal nerve the differences were significant in conduction velocity and F-wave, while for tibial nerve the differences were significant in all studies parameters. Özdemir *et al*.[6] reported that conduction velocities of tibial and peroneal nerves were significantly lower in stain-users.

The explanation to these variations in results might be related to difference in statin type in each study, along with difference in dosing, duration, and limited control of confounding factors, in addition to the fact that nerve conduction examination is somewhat operator dependent.[12] There are some proposed mechanisms for explaining the effects of statins on peripheral nerves; one is the indirect effect of statins in lowering levels of alfa-tocopherol, which is a form of Vitamin E, through lowering low-density lipoproteins which are responsible for its transport,[13] in addition the decrement in cholesterol affect the cell membrane of neurons.[14] This is supported by the results of Jende *et al*.,[15] who reported that patients with lower levels of serum cholesterol had higher rate of peripheral neuropathies. Another mechanism is that statins decrease levels of serum coenzyme Q10 (ubiquinone) by inhibiting its synthesis.[16] On the other hand, the reason why some investigators believe that statins might actually reduce peripheral neuropathy risk is the anti-inflammatory effects of these medications.[17]

Age and sex association with peripheral neuropathy

In the current study, only age showed statistically significant difference among cases with peripheral neuropathy being older in patients with peripheral neuropathy, This is may be attributable to age-related changes and other disorders that frequently coexist in elderly persons and polypharmacy that increase interaction.

In addition to that rate of PN was higher in males. This was in concordance to results of Tierney *et al.,*[18]

who reported that advanced age was a risk factor for developing peripheral neuropathy in patients on statins, in addition to male gender, black race, higher BMI and very low economic level. The studies by Jha *et al*.[19] reported that risk for developing PN in stain-users was not associated with sex or comorbidities, whereas Attardo *et al*.[20] mentioned in their review about statins-related neuromuscular side effects, listed the following risk factors: Advanced age, female gender, descendant from Asia, co-administration with medication affecting levels of statins in plasma, strenuous exercise, already having renal, hepatic or muscle disease, hypothyroidism, high BMI and vitamin D deficiency

Statins type, dose and peripheral neuropathy

The use of atorvastatin was associated with increased risk for developing peripheral neuropathy. Adverse events with statin may be related to their solubility, by passive diffusion, can enter cells and spread broadly throughout various tissues.

This result was very close to results of Lehrer and Rheinstein,[21] who reported that patients taking atorvastatin had 5.20 folds risk for developing peripheral neuropathy, and follow by fluvastatin 5.80 folds, and it is attributed to the high lipophilic nature of these two agents, whereas the lowest risk was for rosuvastatin and pravastatin because both are hydrophilic. In a meta-analysis that enrolled nine studies concerning statin related PN, which was conducted by Wang *et al*. (2021)[22], and they concluded that using statin did not show a statistically significant increment in risk for developing PN. And other factors like the duration of follow-up, study designs, adjusted relative risk, number of patients enrolled and place of study, all were not associated with developing PN.[23]

In this study, no significant difference was observed in the incidence of peripheral neuropathy with different doses of atorvastatin and rosuvastatin, this result was close to results by Özdemir *et al*.[6] There was no significant difference in the frequency of polyneuropathy between groups taking different dosages of atorvastatin and rosuvastatin.[6]

Conclusion

Statin consumption can cause changes in the peripheral motor and sensory nerves and increase risk of peripheral neuropathy with statin exposure. However, awareness the side effects would lead to better treatment.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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