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Nerve Conduction Studies in Post-COVID 19 Patients among Egyptian Patients

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ABSTRACT

Introduction: Corona viruses are large family of viruses which may cause disease in animals or humans. The most common symptoms are fever, cough, sneezing and shortness of breath. Extra-pulmonary manifestations include thromboembolism, renal, hepatic, gastrointestinal, endocrine, cardiac, dermatological and neurological manifestations. The neurological manifestations include headache, dizziness, encephalopathy, Guillen-barre, myalgia, stroke and insomnia. However, it has not been reported that patients with COVID-19 have any neurological manifestations.

Aim: The aim of the study is to demonstrate the presence of neurological manifestations through nerve conduction studies among Egyptian post-COVID patients and its correlation with CRP levels.

Methods: A comparative cross-sectional study of 90 post-COVID male patients, thirty patients were had mild symptoms during the disease activity, 30 had moderate symptoms and 30 had severe symptoms. In addition, 30 healthy control subjects that had no history of COVID-19 infection were included. Full History taking, Radiological, laboratory and neurological assessments were performed. Nerve conduction studies involve assessment of nerves of both upper and lower limbs.

Results: There was a statistically significant difference as regards presence of symptoms and CRP levels in severe group in comparison to the other two groups. There was positive correlation between CRP levels and motor and sensory nerve latency, amplitude, and conduction velocity. No significant difference as regards F waves.

Conclusion: COVID-19 may affect nervous system as well as respiratory system. This study offered new clinical information on COVID-19 which would help to raise awareness of involvement of nervous system. Patients who suffered from severe COVID infection have greater chance of neurological involvement. Also, there was positive correlation between CRP and both delayed latencies and conduction velocities in all nerves in severe post-COVID group.

Key Words: SARS: severe acute respiratory syndrome, MERS: Middle East respiratory syndrome, COVID-19: Corona virus 2019, rRT-PCR: reverse transcription polymerase chain reaction, CRP: C reactive protein, CMAP: motor nerve compound muscle action potential.

INTRODUCTION

Corona viruses are large family of viruses which may cause disease in animals or humans. They usually cause respiratory infection ranging from common cold to severe infectious diseases such as severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS) and the recently discovered corona virus (COVID-19).¹ Corona virus disease 2019 (COVID-19) is an RNA virus with atypical crown like appearance under an electron microscope due to the presence of glycoprotein spikes on its envelope.² The virus rapidly spread from one person to another via respiratory droplets

produced sneezing and coughing. For symptoms to appear it take from two to fourteen days with average five days. It is considered most contagious when people are symptomatic, although there is possible transmission before symptoms appear in patients.³

The standard tool for diagnosis is by reverse transcription polymerase chain reaction (rRT-PCR) either from throat swab or nasopharyngeal swab. It can also be diagnosed by combination of symptoms, risk factors and chest CT showing features of pneumonia.⁴ Preventive measures are recommended as covering the mouth when coughing, maintaining

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one-meter distance from people, washing hands with soap and self-isolation for fourteen days for suspected people to infection.⁵ The most common symptoms are fever, cough, sneezing and shortness of breath. Respiratory complications include pneumonia, throat pain and acute respiratory distress syndrome.⁵ Also, COVID-19 is associated with deleterious effects on many other organ systems. Extra-pulmonary manifestations include thromboembolism, renal, hepatic, gastrointestinal, endocrine, cardiac, dermatological and neurological manifestations. The neurological manifestations include headache, dizziness, encephalopathy, Guillen-barre, myalgia, stroke and insomnia. However, it has not been reported that patients with COVID-19 have any neurological manifestations.⁶ The aim of the study is to demonstrate the presence of neurological manifestations through nerve conduction studies among Egyptian post-COVID patients and its correlation with CRP levels.

PATIENTS & METHODS

Patients, Study Design

A comparative cross-sectional study, a convenient sample of 90 post-COVID male patients were recruited from outpatient clinic of Ain Shams University Hospitals in their follow up over 3 months. Thirty patients had mild COVID symptoms during the disease activity (were treated at home), 30 had moderate symptoms (were treated at isolation hospitals) and 30 had severe symptoms during the disease activity (were treated at ICU units in the isolation hospitals). In addition, 30 healthy control subjects that had no history of COVID-19 infection were included. All patients and controls were recruited from the outpatient clinics of Ain Shams University Hospitals which were assigned by government to treat patients with COVID-19. A confirmed case of COVID-19 was defined as a positive result of reverse transcription polymerase chain reaction analysis of throat swab. Throat swab samples were collected and placed in tubes containing preservation solutions for viruses.⁷ Before enrollment and after explanation of the study, a written consent was obtained from all participants. Ethical approval was obtained from the ethical committee of Ain Shams University.

Clinical assessment

All patients were subjected to; 1- full medical history taking with special concern about onset and disease duration and drug history, 2- clinical examination (general and neurological), 3- laboratory investigation: 3 cm blood sample was withdrawn to assess CRP (C reactive protein) level, FBS (fasting blood sugar) and CBC (complete blood picture), 4- throat swab and PCR (polymerase chain reaction) to exclude recent COVID infection, 5- CT scan chest without contrast, 6- finally, nerve conduction studies for both upper and lower

limbs nerves was performed. Patients with history of malignancy, diabetes mellitus, autoimmune diseases, pacemaker, active infection, with other neurological diseases, chronic obstructive pulmonary disease, severe uncontrolled medical illness, alcohol or drug abuse or using hormonal therapy were excluded from the study.

Nerve Conduction Studies

Nerve conduction studies involve stimulation of nerves of both upper and lower limbs. Surface electrodes were used to deliver and detect electric responses. Most subjects described its electric impulse as tapping or tingling sensation. Subjects should avoid application of topical creams prior to nerve conduction study. No fasting is required and the subject can return to his normal activities after the study. The test is safe and well tolerated with minor discomfort and no long-term side effects. The nerve conduction study was done in outpatient room setting. It took between 40 minutes to an hour. Nerve conduction study is a test commonly used to evaluate the function of motor and sensory nerves in both limbs. The study included the evaluation of the motor and sensory fibers of median and ulnar nerves in upper extremities and the motor and sensory fibers of peroneal and tibial nerves in lower extremities. Recording was obtained from the muscle supplied by the nerve distal to the site of stimulation using two surface electrodes, active electrode over muscle belly and reference electrode over muscle tendon. For motor nerves, compound muscle action potential (CMAP) was created due to summation of activated muscle fibers. For sensory nerves, a propagated sensory nerve action potential was obtained also in the same manner. The parameters which were obtained and used for interpretation includes: 1- latency (ms) from stimulus to onset of evoked response, 2- amplitude (mv) from baseline to peak which reflects the number of conducting fibers and reduced in axonal loss, and 3- conduction velocity (m/s) which measures through distance between stimulation and the recording points divided by latency, it reflects the integrity of myelin sheath necessary for impulse conduction and reduced in demyelinating nerves. 4- Also, F-wave late response was done to assess proximal segments of peripheral nervous system including plexus and nerve roots.⁸

Statistical Analyses

The collected data was revised, coded, tabulated and introduced to a PC using Statistical Package for Social Science version 20 (SPSS-V20) USA. Data was presented and suitable analysis was done according to type of data obtained for each parameter. Mean $\pm$ SD and range for numerical data, frequency and percentage for non-numerical data. Student T-test was used to compare between two groups in quantitative data. Linear correlation coefficient used to assess the strength of association between non-parametric variables in

same group. ANOVA test was used for comparison among different times in the same group in quantitative data. Results were considered significant at $p \leq 0.05$, highly significant at $p \leq 0.001$.

RESULTS

The study included 30 mild post-COVID patients, 30 moderate post-COVID, 30 severe post-COVID patients, and 30 healthy controls. The age ranged in mild group from 21 to 58 years with mean of 40.9 ± 11.3 , in moderate group ranged from 23 to 60 years with mean of 39.5 ± 11.2 , in severe group ranged from 22 to 55 years with mean of 38.5 ± 10.7 , while in the control group the age ranged from 20 to 61 years with mean of 41.6 ± 11.7 . Neurological symptoms (reduced muscle tone, muscle weakness) were present in one patient in mild post-COVID group, four patients in moderate post-COVID group, and 11 patients in severe post-COVID group. The CRP levels ranged from 11 to 20 mg/L in mild post-COVID with mean of 15.2 ± 2.8 , ranged from 21 to 35 mg/L in moderate post-COVID with mean of 26 ± 3.7 , ranged from 36 to 50 mg/L in severe post-COVID with mean of 42.3 ± 4.3 , while in the control group it ranged from 3 to 9.8 mg/L with mean of 6.7 ± 1.88 . The right median nerve motor latency in mild post-COVID group ranged from 2.7 to 4.4 ms with mean of 3.1 ± 0.3 , in moderate post-COVID group it ranged from 2.5 to 3.6 ms with mean of 2.8 ± 0.27 , in severe post-COVID group it ranged from 2.5 to 5 ms with mean of 3.37 ± 0.69 , while in the control group it ranged from 2.4 to 3.6 ms with mean of 2.98 ± 0.33 . The right motor median nerve amplitude in mild post-COVID group ranged from 7.1 to 13.3 mv with mean of 10 ± 1.77 , in moderate post-COVID it ranged from 7.5 to 15 mv with mean of 10.82 ± 1.99 , in severe post-COVID group it ranged from 8.5 to 13.3 mv with mean of 11.2 ± 1.29 , while in control group it ranged from 8.5 to 15 mv with mean of 11.2 ± 1.66 . The right median nerve motor conduction velocity in mild post-COVID group ranged from 51 to 70 m/s with mean of 58.9 ± 5.4 , in moderate post-COVID it ranged from 48 to 66 m/s with mean of 54 ± 4.5 , in severe post-COVID group it ranged from 45 to 65.9 m/s with mean of 54.9 ± 4.66 , while in the control group it ranged from 50 to 65 m/s with mean of 56.86 ± 4.3 . The left ulnar nerve motor latency in mild post-COVID group ranged from 2.6 to 3.7 ms with mean of 2.92 ± 0.2 , in moderate post-COVID group it ranged from 2.5 to 3.6 ms with mean of 2.88 ± 0.26 , in severe post-COVID group it ranged from 2.3 to 3.6 ms with mean of 2.92 ± 0.355 , while in the control group it ranged from 2.4 to 3.1 ms with mean of 2.72 ± 0.2 . The left ulnar nerve motor amplitude in mild post-COVID group ranged from 8.5 to 13.1 mv with mean of 11.04 ± 1.26 , in moderate post-COVID group it ranged from 7.5 to 15.1 mv with mean of 11.3 ± 2.07 , in severe post-COVID group it ranged from 8.9 to 13 mv with mean of 11.01 ± 1.14 , while in the control group it

ranged from 6.9 to 13.1 mv with mean of 10.32 ± 1.8 . The left ulnar nerve motor conduction velocity in mild post-COVID group ranged from 51 to 75 m/s with mean of 62.57 ± 6.44 , in moderate post-COVID group it ranged from 49 to 70.3 m/s with mean of 58.95 ± 6.52 , in severe post-COVID group it ranged from 44 to 65 m/s with mean of 53.86 ± 4.82 , while in the control group it ranged from 49.5 to 63 m/s with mean of 55.82 ± 3.86 .

The right tibial nerve motor latency in mild post-COVID group ranged from 3.5 to 5.8 ms with mean of 3.98 ± 0.45 , in moderate post-COVID group it ranged from 3.3 to 6.3 ms with mean of 4.187 ± 0.8 , in severe post-COVID group it ranged from 3.5 to 6.6 ms with mean of 4.66 ± 1.045 ms, while in the control group it ranged from 2.9 to 4.6 ms with mean of 3.65 ± 0.45 . The right tibial nerve amplitude in mild post-COVID group ranged from 7.3 to 15.1 mv with mean of 10.99 ± 1.78 , in moderate post-COVID group it ranged from 7 to 16 mv with mean of 11.79 ± 2.33 , in severe post-COVID group it ranged from 8.6 to 13.5 mv with mean of 11.49 ± 1.35 , while in the control group it ranged from 9.9 to 15 mv with mean of 12.05 ± 1.82 . The right tibial nerve motor conduction velocity in mild post-COVID group ranged from 49 to 57.2 m/s with mean of 52.213 ± 2.17 , in moderate post-COVID group it ranged from 41 to 55 m/s with mean of 50.23 ± 3.67 , in severe post-COVID group it ranged from 40 to 57.1 m/s with mean of 48.9 ± 6.19 , while in the control group it ranged from 49 to 70 m/s with mean of 57.21 ± 6.18 . The left peroneal nerve motor latency in mild post-COVID group ranged from 2.5 to 6.6 ms with mean of 3.08 ± 0.72 , in moderate post-COVID group it ranged from 2.7 to 7.1 ms with mean of 3.81 ± 1.29 in, in severe post-COVID group it ranged from 3.3 to 7.5 ms with mean of 5 ± 1.5 , while in the control group it ranged from 2.9 to 4.5 ms with mean of 3.76 ± 0.41 . The left peroneal nerve motor amplitude in mild post-COVID group ranged from 6.5 to 9.1 mv with mean of 8.06 ± 0.7 , in moderate post-COVID group it ranged from 8 to 11.1 mv with mean of 9.58 ± 0.92 , in severe post-COVID group it ranged from 8 to 13 mv with mean of 10.48 ± 1.33 , while in the control group it ranged from 9.9 to 14 mv with mean of 11.99 ± 1.207 . The left peroneal nerve motor conduction velocity in mild post-COVID group ranged from 49 to 60.1 m/s with mean of 54.716 ± 3.53 , in moderate post-COVID group it ranged from 41 to 63 m/s with mean of 54.413 ± 5.81 , in severe post-COVID group it ranged from 40.5 to 60 m/s with mean of 49.44 ± 6.31 , while in the control group it ranged from 49.5 to 66 m/s with mean of 56.49 ± 4.67 .

F-wave latency of the right median nerve in mild post-COVID group ranged from 25 to 30 ms with mean of 27.7 ± 1.21 , in moderate post-COVID group it ranged from 27 to 30 ms with mean of 28.4 ± 0.92 , in severe post-COVID group it ranged from 26.7 to 30 ms with mean of 28.5 ± 1.01 , and in the control group it ranged from 25 to 30.5 ms with mean of 27.9 ± 1.41 . F-wave latency of the right tibial nerve in mild post-COVID

ID group ranged from 47 to 55 ms with mean of 49.7 ± 2.09 , in moderate post-COVID group it ranged from 47.5 to 55 ms with mean of 50.36 ± 1.94 , in severe post-COVID group it ranged from 47.5 to 54.3 ms with mean of 50.2 ± 1.92 , and in the control group it ranged from 46 to 55 ms with mean of 50.8 ± 2.22 . The right median sensory latency in mild post-COVID group ranged from 1.4 to 2.9 ms with mean of 1.8 ± 0.62 , in moderate post-COVID group it ranged from 1.7 to 3.4 ms with mean of 2.34 ± 0.36 , in severe post-COVID group it ranged from 1.9 to 3.8 ms with mean of 3.1 ± 0.32 , while in the control group it ranged from 1.5 to 3 ms with mean of 1.9 ± 0.66 . The right median sensory conduction velocity in mild post-COVID group ranged from 49.3 to 60.6 m/s with mean of 56.5 ± 6.4 , in moderate post-COVID group it ranged from 41.5 to 63.2 m/s with mean of 51.4 ± 6.2 , in severe post-COVID group it ranged from 38.2 to 58.8 m/s with mean of 47.6 ± 8.2 , while in the control group it ranged from 49.7 to 62 m/s with mean of 55 ± 6.5 . The left ulnar sensory latency in mild post-COVID group ranged from 2.6 to 3.2 ms with mean of 2.9 ± 0.38 , in moderate post-COVID group it ranged from 2.8 to 4.6 ms with mean of 3.2 ± 0.28 , in severe

post-COVID group it ranged from 2.6 to 4.9 ms with mean of 4.2 ± 0.1 , while in the control group it ranged from 2.8 to 3.1 ms with mean of 2.9 ± 0.33 . The left ulnar sensory conduction velocity in mild post-COVID group ranged from 47.8 to 56.2 m/s with mean of 51.8 ± 7.2 , in moderate post-COVID group it ranged from 41.1 to 56.4 m/s with mean of 50.9 ± 8.3 , in severe post-COVID group it ranged from 36.7 to 58.2 m/s with mean of 44.8 ± 6.9 , while in the control group it ranged from 49 to 57 m/s with mean of 51 ± 7.4 . The right sural sensory latency in mild post-COVID group ranged from 1.7 to 4.2 ms with mean of 2.8 ± 0.63 , in moderate post-COVID group it ranged from 2.1 to 5.2 ms with mean of 3.6 ± 0.21 , in severe post-COVID group it ranged from 2.4 to 7.2 ms with mean of 5.2 ± 0.34 , while in the control group it ranged from 1.7 to 3.6 ms with mean of 2.8 ± 0.34 . The right sural sensory conduction velocity in mild post-COVID group ranged from 42.3 to 65.2 m/s with mean of 50.3 ± 6.4 , in moderate post-COVID group it ranged from 38.9 to 53.6 m/s with mean of 48.6 ± 4.2 , in severe post-COVID group it ranged from 33.2 to 52.8 m/s with mean of 41.5 ± 6.2 , while in the control group it ranged from 45 to 67 m/s with mean of 53 ± 5.4 (Table 1).

Table 1: Demographic and clinical data of the patient groups and controls.

	Mild (mean± SD)	Moderate (mean± SD)	Severe (mean± SD)	Control (mean± SD)
Age	21-58 (40.9±11.39)	23-60 (39.5± 11.243)	22-55 (38.56± 10.74)	20-61 (41.6±11.79)
Symptoms	1	4	11	0
CRP	11-20 (15.24±2.81)	21-35 (26.04±3.7)	36-50 (42.3±4.311)	3-9.8 (6.72±1.88)
Median motor latency	2.7-4.4 (3.10±0.34)	2.5-3.6 (2.86±0.27)	2.5-5 (3.37±0.693)	2.4-3.6 (2.98±0.33)
Median motor amplitude	7.1-13.3 (10.01±1.77)	7.5-15 (10.82±1.99)	8.5-13.3 (11.2±1.29)	8.5-15 (11.2±1.66)
Median motor CV	51-70 (58.9±5.4)	48-66 (54.01±4.57)	45-65.9 (54.95±4.66)	50-65 (56.8±4.36)
Ulnar motor latency	2.6-3.7 (2.9±0.2)	2.5-3.6 (2.88±0.26)	2.3-3.6 (2.9±0.355)	2.4-3.1 (2.7±0.2)
Ulnar motor amplitude	8.5-13.1 (11.043±1.26)	7.5-15.1 (11.3±2.07)	8.9-13 (11.017±1.14)	6.9-13 (10.32±1.8)
Ulnar motor CV	51-75 (62.5±6.44)	49-70.3 (58.95±6.52)	44-65 (53.86±4.82)	49.5-63 (55.8±3.86)
Tibial motor latency	3.5-5.8 (3.9±0.45)	3.3-6.3 (4.18±0.8)	3.5-6.6 (4.66±1.04)	2.9-4.6 (3.6±0.45)
Tibial motor amplitude	7.3-15.1 (10.99± 1.78)	7-16 (11.79±2.33)	8.6-13.5 (11.49±1.359)	9.9-15 (12.05±1.182)
Tibial motor CV	49-57.2 (52.21±2.17)	41-55 (50.23±3.67)	40-57.1 (48.9±6.19)	49-70 (57.21±6.182)
Peroneal motor latency	2.5-6.6 (3.08±0.722)	2.7-7.1 (3.81±1.29)	3.3-7.5 (5±1.502)	2.9-4.5 (3.76±0.41)
Peroneal motor amplitude	6.5-9.1 (8.06±0.7)	8-11.1 (9.58± 0.92)	8-13 (10.48±1.33)	9.9-14 (11.99±1.2)

Table 1: (Continued)

	Mild (mean± SD)	Moderate (mean± SD)	Severe (mean± SD)	Control (mean± SD)
Peroneal motor CV	49-60.1 (54.71±3.53)	41-63 (54.4±5.81)	40.5-60 (49.44±6.31)	49.5-66 (56.4± 4.67)
F median latency	25-30 (27.7±1.21)	27-30 (28.42±0.92)	26.7-30 (28.5±1.014)	25-30.5 (27.9±1.41)
F tibial latency	47-55 (49.76±2.09)	47.5-55 (50.36±1.94)	47.5-54.3 (50.21±1.92)	46-55 (50.8±2.22)
Sensory median latency	1.4-2.9 (1.8±0.62)	1.7-3.5 (2.34±0.36)	1.9-3.9 (3.1±0.32)	1.3-2.8 (1.5±0.51)
Sensory median CV	49.3-60.6 (56.5±6.4)	41.5-63.2 (51.4± 6.2)	38.2-58.8 (47.6±8.2)	52- 65 (57±5.3)
Sensory ulnar latency	2.6-3.2 (2.9±0.38)	2.8-4.6 (3.2±0.28)	2.6-4.9 (4.2±0.1)	2.5-3 (2.8±0.37)
Sensory ulnar CV	47.8-56.2 (51.8±7.2)	41.1-56.4 (50.9±8.3)	36.7-58.2 (44.8± 6.9)	55-68 (58±4.5)
Sensory sural Latency	1.7-4.2 (2.8± 0.63)	2.1-5.2 (3.6± 0.21)	2.4-7.2 (5.2± 0.34)	1.7-4.1 (2.7±0.66)
Sensory sural CV	42.3-65.2 (50.3± 6.4)	38.9-53.6 (48.6± 4.2)	33.2-52.8 (41.5±6.2)	44-64 (49±5.1)

There was no statistical difference as regards age between the three groups and the control group. There was a statistically significant difference as regards presence of symptoms and CRP levels in severe post-COVID group in comparison to the other two groups. Also, there was a highly statistically significant difference as regards right median nerve motor latency and median nerve motor conduction velocity and a statistically significant difference as regards right median nerve amplitude in severe post-COVID group. There was a statistically significant difference as regards ulnar nerve latency and a highly statistical difference as regards ulnar conduction velocity and no statistical difference as regards in ulnar nerve amplitude in severe post-COVID group. There was a highly statistically significant difference as regards tibial nerve latency and tibial conduction velocity and no statistical difference as regards in tibial nerve amplitude in severe post-COVID group. There was a highly statistically significant difference as regards peroneal nerve latency, peroneal conduction velocity and peroneal nerve amplitude in severe post-COVID group (Table 2).

Table 2: Relation between severe post-COVID group with clinical, laboratory and nerve conduction studies.

Severe group	p value	Significance
Age	0.726	NS
Symptoms	<0.001	HS**
CRP	<0.001	HS**
Median motor latency	<0.001	HS**

Median motor ampli- tude	0.024	NS
Median motor CV	0.001	S*
Ulnar motor latency	0.008	NS
Ulnar motor amplitude	0.111	NS
Ulnar motor CV	<0.001	HS**
Tibia motor latency	<0.001	HS**
Tibial motor amplitude	0.105	NS
Tibial motor CV	<0.001	HS**
Peroneal motor latency	<0.001	HS**
Peroneal motor ampli- tude	<0.001	HS**
Peroneal motor CV	<0.001	HS**
F median latency	0.027	NS
F tibial latency	0.276	NS
Sensory median latency	0.001	S*
Sensory median CV	0.001	S*
Sensory ulnar latency	<0.001	HS**
Sensory ulnar CV	<0.001	HS**
Sensory sural Latency	<0.001	HS**
Sensory sural CV	<0.001	HS**

Using ANOVA test, *Sig: p values ≤ 0.05, ** highly sig: p ≤ 0.001

In mild post-COVID group there was positive correlation between CRP levels and each of tibial nerve amplitude, peroneal nerve latency and peroneal nerve amplitude. In moderate post-COVID group there was positive correlation between CRP levels and each of median nerve amplitude, median

nerve conduction velocity and tibial nerve amplitude. While, there was a highly statistical correlation between ulnar nerve amplitude, ulnar conduction velocity, tibial nerve latency, tibial conduction velocity, peroneal nerve latency and peroneal conduction velocity. In severe post-COVID group, there was positive correlation between CRP levels and each of age,

median nerve latency, median conduction velocity, ulnar nerve latency, ulnar conduction velocity, peroneal amplitude and peroneal conduction velocity, while there was highly positive correlation between CRP levels and each of tibial nerve latency, amplitude, conduction velocity and peroneal nerve latency (Table 3).

Table 3: Correlation between CRP levels with clinical and nerve conduction studies.

	CRP					
	Mild Group		Moderate Group		Severe Group	
	p value	Sig	p value	Sig	p value	Sig
Age	0.746	NS	0.558	NS	0.034	NS
Symptoms	0.331	NS	0.001	S*	<0.001	HS**
Median motor latency	0.090	NS	0.598	NS	0.002	NS
Median motor amplitude	0.321	NS	0.010	NS	0.291	NS
Median motor CV	0.678	NS	0.054	NS	0.043	NS
Ulnar motor latency	0.181	NS	0.368	NS	0.010	NS
Ulnar motor amplitude	0.633	NS	0.001	S*	0.683	NS
Ulnar motor CV	0.575	NS	0.008	NS	0.007	NS
Tibia motor latency	0.152	NS	0.001	S*	<0.001	HS**
Tibial motor amplitude	0.007	NS	0.053	NS	<0.001	HS**
Tibial motor CV	0.764	NS	<0.001	HS**	<0.001	HS**
Peroneal motor latency	0.032	NS	<0.001	HS**	<0.001	HS**
Peroneal motor amplitude	0.048	NS	0.156	NS	0.008	NS
Peroneal motor CV	0.419	NS	<0.001	HS**	0.001	S*
F median latency	0.855	NS	0.681	NS	0.771	NS
F tibial latency	0.256	NS	0.323	NS	0.509	NS
Sensory median latency	0.234	NS	0.001	S*	<0.001	HS**
Sensory median CV	0.213	NS	0.001	S*	0.001	S*
Sensory ulnar latency	0.211	NS	0.001	S*	<0.001	HS**
Sensory ulnar CV	0.016	NS	0.001	S*	0.001	S*
Sensory sural Latency	0.015	NS	<0.001	HS**	<0.001	HS**
Sensory sural CV	0.231	NS	<0.001	HS**	<0.001	HS**

Linear Correlation Coefficient Test, ANOVA test, Sig: p values ≤ 0.05, ** highly sig: p ≤ 0.001.

DISCUSSION

The Corona virus pandemic is the defining global health crisis of our time. The situation of COVID-19 pandemic in Egypt as compared to other parts of the world is promising.⁹ Egypt is one of the countries trying to flatten the curve of new infections of COVID-19 pandemic.¹⁰ Neurological manifestations of coronavirus-19 are increasingly recognized as a major complication with potential long-term consequences for both patients and health care system. Mao et al. reported neurological symptoms in approximately 36% of confirmed corona virus.¹¹ Patients with severe COVID-19 infections

are at risk of developing neurological manifestations especially acute cerebrovascular disease and manifestations of peripheral nervous system are less frequently reported.¹² Our study aimed to demonstrate the presence of neurological manifestations among Egyptian post-COVID and its correlation with the inflammatory marker (CRP). There was no statistical difference between the three patient groups and control as regards age and sex, which was agreed with the study done by Frithiof et al.¹² There was highly statistically significant difference between presence of symptoms in three patient groups and control which agreed with Ottaviani et al. who had reduced muscle tone and presence of muscle

weakness.¹³ The CRP levels showed highly significant relation between three patient groups and control, which was in agreement with a case reported high CRP levels in severe COVID infection in female patient¹³ but was not in agreement with another case reported study who showed normal levels of CRP levels.¹⁴ A case Report was done which was in agreement with our study as regards delayed latencies of both lower limbs denoting presence of demyelination with average conduction velocity which was not in agreement with our study in all nerves. This case report study didn't study upper limbs.¹⁵ Our study showed delayed latencies, partial conduction block in both upper and lower limbs denoting polyneuropathy which was in agreement with a case report done by Daia C.¹⁶ F-waves in our study were within average values which were not in agreement with case report which showed absence of F-waves while some patients showed average and other showed absence.¹² Sensory nerve conduction studies showed average peak latencies, average conduction velocities of right median and left ulnar nerves while showed delayed peak latency of right sural nerve in mild group. In moderate and severe groups, there were delayed peak latencies of all sensory examined nerves (median, ulnar and sural) while another study calculated the combined motor and sensory amplitude scores as mean amplitude of recorded nerves.¹² In our study, there was positive correlation between CRP levels and age. Also, there was positive correlation between CRP and both delayed latencies and conduction velocities in all nerves in severe post-COVID group (median, ulnar, tibial and peroneal). There is positive correlation between CRP levels and decreased amplitude in both tibial and peroneal nerves in severe group. There was no positive correlation between CRP levels and both F-waves.

CONCLUSION:

COVID-19 may affect nervous system as well as respiratory system. Patients which suffered from severe COVID infection have greater chance of neurological involvement. Also, there was positive correlation between CRP and both delayed latencies and conduction velocities in all nerves in severe post-COVID group. This study offered new clinical information on COVID-19 which may help to raise awareness of involvement of nervous system.

RECOMMENDATIONS

Clinicians should consider COVID infection as a differential diagnosis to avoid delayed diagnosis or misdiagnosis of post-COVID neurological manifestations. More studies are needed due to dynamic nature of the pandemic for forecasting and preparedness in different scenarios.

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