Original research article

The Nerve Conduction Study in Patients with Guillain Barre Syndrome and Normal Healthy Controls

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Abstract
The Nerve Conduction Studies (NCS) are essential in the differential diagnosis of Guillain Barre syndrome (GBS). Finding the earliest and most common electrophysiological variables affected during early 0-3 days of illness promises to improve the patients' overall prognosis. Keeping these facts, we studied the various nerve conduction parameters in GBS patients to explore the extent and the earliest and most common parameters involved during illness. For these 30 diagnosed cases of GBS, the same numbers of normal healthy controls were taken for study. The parameters studied were the distal motor and sensory latency (DL), nerve conduction velocity (NCV), minimal F wave latency, compound motor and sensory nerve action potential (CAMP), and H reflex. As per our result, acute inflammatory demyelinating polyneuropathy (AIDP) formed the most common variant in 53.33% of cases, followed by acute motor axonal neuropathy (AMAN) in 23.35%, acute motor and sensory axonal neuropathy (AMSAN) in 3.33%, uncharacterized (16.67%) and unexcitable (3.3%). In cases with a p-value of<.05, mean motor DL, CMAP, and NCV were significantly reduced in the tibial, peroneal, ulnar, and median nerves**.** The F wave minimum latency reduction was also significant, with a p-value of <.05. H reflex was absent in overall 89.28 % of cases. During early 0-3 days, F-wave and H reflex were the most common findings and were aberrant in 76.92% and 83.33% of cases, respectively.
Keywords: Nerve Conduction Velocity (NCV), Distal Motor and sensory Latency, Compound Motor and Sensory Nerve Action Potential, H-reflex, F-wave

Introduction

Guillain–Barré syndrome (GBS) is an acute polyneuropathic disorder affecting the peripheral nervous system. It is a heterogeneous condition associated with immune-mediated self-limiting peripheral neuropathies. [1, 2] It constitutes the leading cause of acute flaccid paralysis (AFP) in western countries and developing countries, including India after polio eradication. [3,4] Nerve conduction studies (NCS) play a key role in its differential diagnosis and in the early identification of its various subtypes. So, these studies can help to identify the

demyelinating variety of GBS from the axonal subtype where severe motor deficit and conduction block have a greater chance of complication and residual disability.[5] Keeping these facts, and very limited studies available in India addressing this problem, our present study was framed to analyze in detail the various electrophysiological parameters of the NCS affected in GBS patients, with a focus on findings occurring as early as 0-3 days of illness, with respect to 30 age and sex-matched healthy controls, Inclusion of these electrophysiological parameters in routine investigation holds promise to the early case detection and in prompt intervention with a potential of improving overall prognosis.

Material and methods

This was a potential case-controlled observational hospital-based study conducted in the Department of Physiology on patients referred from the Department of Neurology with a presumptive detection of Guillain-Barre Syndrome (GBS) fulfilling the Asbury and Cornblath specific criteria for case definition of GBS. [6,7]

The electrophysiological experiments were conducted using the NEUROWERK EMG, a product of SIGMA medizing Technik Gmbh Germany, with room temperature maintained between 21 and 23 degrees Celsius and skin temperature of 34 degrees Celsius, as indicated by the manufacturer and standard text. The electrode positioning and nerve stimulation were performed according to Mishra, Kalita, and Shapiro's conventional technique. [8,9]

Under the same laboratory circumstances, 30 diagnosed GBS patients, and the same age and sex-matched healthy individuals were taken as controls. NCS was performed mostly within two weeks of diagnosis. The electrodiagnostic criteria used to identify demyelination and conduction block were distal sensory and motor nerve latency (DL), motor and sensory nerve conduction velocity (NCV), minimum F wave response latency, and distal compound motor and sensory nerve action potential (dCMAP, dSNAP), and H reflex, as these variables, are related to nerve conduction slowing and conduction block. [10]

The nerves studied were median, and ulnar for motor and sensory parameters, and peroneal and tibial nerve for motor parameters, the sural nerve was studied for sensory parameters. The lowest latency of F-waves in the median and tibial nerves was measured by stimulating at a distal motor stimulation location for 10 consecutive stimulations. In the lower leg, the H reflex was detected in the tibial nerve. The electrophysiological classification of GBS subtypes was done according to Hadden et al [11] guidelines, which are as follows:

AIDP (Acute inflammatory demyelinating polyneuropathy)

(At least one of the following in each of at least two nerves, or at least two of the following in one nerve if the others are in excitable and the dCMAP is less than 10% of the lower limit of normal (LLN)

- Motor conduction velocity is less than 90% of the lower limit of normal (85% if dCMAP is less than 50% LLN).
- Distal motor delay is greater than 110 % of the upper limit of normal (120 % if dCMAP is less than 100 percent of the lower limit of normal).
- F-response latency is greater than 120% of the upper limit of normal.
- The pCMAP/dCMAP ratio is less than 0.5, and dCMAP is greater than or equal to 20% of the normal lower limit.

AMAN (Acute motor axonal neuropathy)
(With the exception of one demyelinating feature allowed in one nerve, none of the AIDP features in any nerve if dCMAP is less than 10% of LLN and less than 80% of LLN in at least two nerves.)

- Normal amplitudes of sensory nerve action potentials.

AMSAN (Acute motor and sensory axonal neuropathy)
(If dCMAP is less than 10% of LLN, none of the AIDP features in any nerve are allowed, save for one demyelinating feature in one nerve.)
In at least two nerves, dCMAP is Less than 80% of LLN.
At least two nerves have sensory action potentials with amplitudes less than 50% of the LLN.

Unexcitable
Distal CMAP is absent in all nerves (or is present in only one nerve with a distal CMAP of less than 10% of the LLN).

Unclassified/equivocal
Doesn't precisely suit any other group's criteria.

Inclusion criteria for the patients
The study included all voluntary cases of GBS who were 19 years old or older and met the Asbury and Cornblath [12,13] criteria for case definition.
The following are the criteria used by Asbury and Cornblath[12,13] to define GBS cases:

- The legs and arms becoming progressively weaker.
- Areflexia - a condition in which muscles do not respond to stimuli.

The following are supporting clinical features of diagnosis:

- Symptom progression over days to weeks
- Sign symmetry (relative)
- Mild sensory symptoms or signs
- Involvement of the cranial nerves (bifacial palsy)
- Recovery begins 2-4 weeks after the progression stops.
- Dysfunctional autonomic nervous system
- Lack of fever at onset

Features of the laboratory that aid in diagnosis include:

- Increased CSF protein with a cell density of less than 10 cells /mm 3
- NCS electrodiagnostic characteristics

Inclusion criteria for the control group
All willing healthy persons with age 19 years and above
Absence of any condition affecting the peripheral nerves mentioned in the exclusion criteria

Exclusion criteria

- Persons with a history of intake of neurotoxic drugs like isoniazid, phenytoin, pyridoxine in high doses
- Any underlying hereditary motor/ sensory neuropathies
- Major injury to nerve interfering with nerve conduction studies

- Persons with systemic disease affecting nerves such as known cases of diabetes mellitus, hypothyroidism, nutritional (vitamin B 12) deficiency, alcoholics, acute myelopathies, peripheral vascular disease, myopathies, motor neuron disease, anterior disc protrusion.

The detailed clinical history of the patients was noted, and a thorough general physical examination and systemic examination of the patients and controls was performed. Cranial nerve examination and sensory system examination were also done for all participants of the study. In our study, all patients and controls were of average height. Before starting the trial, patients and controls gave their informed consent. The institutional review board approved the study.

Statistical analysis

The results obtained from the patients and normal healthy controls were analyzed by using SPSS 22 Software. Independent sample tests were used to determine the significance of the variation in the electrophysiological variables of controls and cases, such as Levine's test for equality of variance, t-test for equality of means, and p-values for cases and controls. The mean values of the electrophysiological variables with 2 standard deviations (SD) were taken as the normal range. Patients with distal motor and sensory latency and F wave minimum latency that exceeded the upper limit of normal (ULN) and sensory and motor nerve conduction velocity and compound motor and sensory nerve action potential that fell below the lower limit of normal (LLN) were considered abnormal. The data were analyzed using descriptive statistics to determine the percentage of electrophysiological parameters implicated in cases compared to a healthy control group.

Results

The details of the normative data obtained from the study of the healthy normal age and sex-matched controls are mentioned in **table no1.**

Table 1: Electrophysiological variables (Control), M (motor), S (sensory), DL (distal latency), and F minimum latency (millisecond), Compound motor action potential (milli volts) and sensory action potential is in (microvolts), Nerve velocity in m/sec), SD (standard deviation)

Mean of Electrophysiological parameter and standard deviation (SD)		Nerves studied						
		Median		Ulnar		Tibial (M)	Peroneal (M)	Sural S
		M	S	M	S			
Mean DL with SD in nerve		3.35 ±.354	2.65 ±.267	2.54 ±.260	2.28 ±.301	3.62 ±.869	4.22 ±.568	2.82 ±.452
Mean nerve conduction velocity		58.38 ±4.053	53.39 ±4.599	57.62 ±4.536	54.47 ±6.888	49.51 ±8.305	54.19 ±6.219	46.58 ±6.458
Distal compound motor and sensory action potential amplitude		9.12 ±2.849	33.76 ±12.284	8.02 ±1.634	35.38 ±12.029	11.84 ±3.943	6.68 ±4.310	16.09 ±7.167
F waves minimum latency in millisecond		25.235 ±2.028298				48.35862 ±2.988253		
H reflex findings in the tibial nerve present in	Present					30		
	absent					0		

24 of the 30 patients reported during the first week and of the various electrophysiological variables studied, the variation in cases was statistically significant with a p-value of < .05 in

almost all motor and sensory electrophysiological variables studied, except distal sensory latency in the median and ulnar nerves and sensory NCV in median nerves, where the variation was insignificant with p-value > .05.

Of 30 cases studied and analysed depending on the Hadden's criteria [11] AIDP was the most common type in 53.33% (n=16) followed by AMAN in 23.33% (n=7), AMSAN in 3%(n=1), unexcitable 3% (n=1) and 16.67% (n=5) of the cases was equivocal. **[figure 1]**

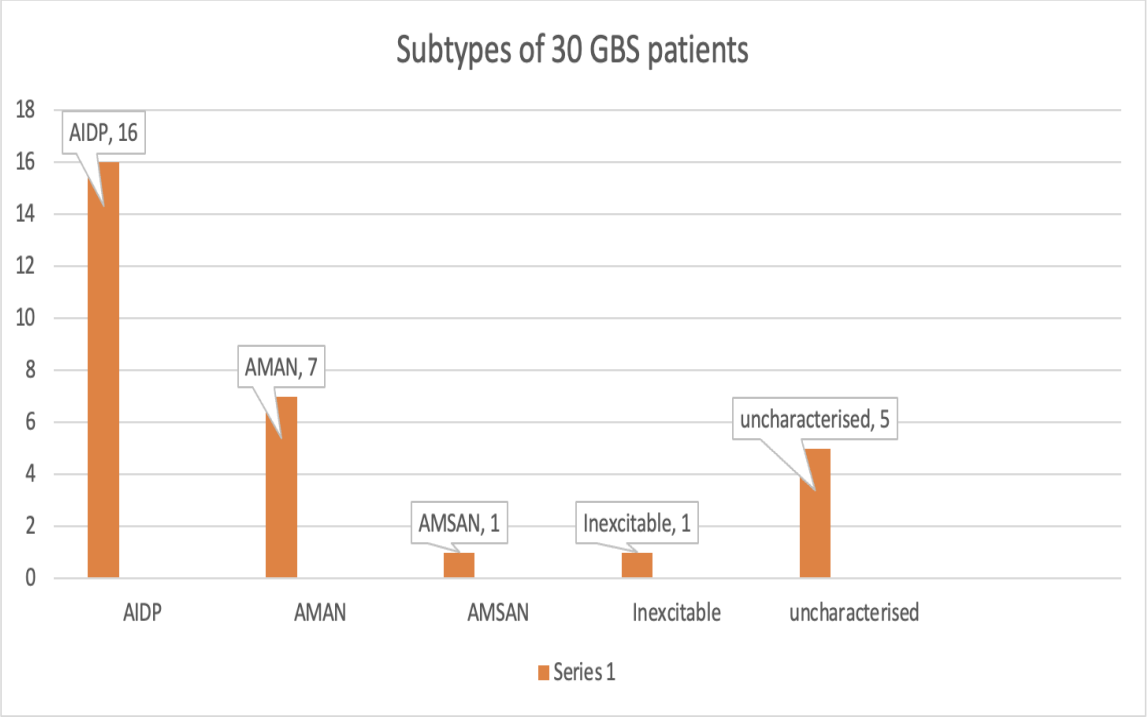

Figure 1: Subtypes of the total 30 GBS patients, AIDP was the most prevalent type detected

Findings in AIDP(N=16) [table 2]

Distal latency was increased in overall 76.56% (n=49, N= 64) of motor nerves studied. Most often it was increased in the median, ulnar, and peroneal nerves each involved in 81.25% (n=13, N=16) of the nerve studied. The overall percentage of conduction blockage was seen in 32.81% (n=21, N= 64) of nerves studied, it was most common in the tibial nerve in 50% (n=8 of 16) of nerves studied. Decreased NCV was seen in overall 57.81 % (n= 37, N=64) of nerves studied, of which median nerve was most affected in 75% (n= 12, N=16)) of the nerve studied.

As regards the sensory findings, distal latency was increased in 9.09% (n=4, N=44) of total nerves studied, of which the median nerve was most involved in 18.75% (n=3, N=16). Decreased sensory nerve action potential amplitude was seen in 45.4 % (n=20, N=44) of nerves studied and the ulnar nerve was most affected in 50% (n=8, N=16) of nerves studied. Reduced NCV was seen in 15.90% (n=7, N=44) of the total nerve studied, of which the sural nerve was most affected in 25% (n=3, N=12). F- wave minimum latency was prolonged in 33.33% (n=5, N=15) in median and 12.5% (n=2, N=16) in tibial nerve. It was absent in 60% (n=9, N=15) in median and 62.5 % (n=10, N=16) in tibial nerves, respectively. H- reflex was absent in 93.33% (n=14, N=15) of the cases.

Table 2: Findings in AIDP (N=13) patients, M (motor), S (sensory), n=numbers of abnormalities detected, N=total number studied, LLN (Lower Limit of Normal), ULN (Upper Limit of Normal), snap (sensory nerve action potential in microvolts)

Electrophysiological parameters		Nerve studied								
		Median N=16		Ulnar N=16		Peroneal N=16	Tibial N=16	Sural (N=12)	Total (motor N=64, sensory N=44)	
		M	S	M	S	Motor (M)		Sensory	M	S
Percentage of increased distal latency > ULN in cases		81.25% (n=13)	18.75% (n=3)	81.25% (n=13)	6.25% (n=1)	81.25% (n=13))	62.5% (n=10))	0 (n=0)	76.56% (n=49)	9.09% (n=4)
Percentage of decreased NCV in cases < LLN		75% (n=12)	18.75% (n=3)	62.5% (n=10)	6.25% (n=1)	62.5% (n=10)	31.25% (n=5)	25% (n=3)	57.81% (n=37)	15.90% (n=7)
Percentage of conduction block in motor nerve & decreased snap amplitude in cases		12.5% (n=2)	43.75% (n=7)	25% (n=4)	50% (n=8)	43.75% (n=7)	50% (n=8)	41.66% (n=5)	32.8% (n=21)	45% (n=20)
F wave abnormality in median & tibial nerve	Prolonged	33.33% (n=5, N=15)					12.5% (n=2, N=16)		93.33% (n=14, N=15) Abnormal median F wave	
	Absent	60% (n=9, N=15)					62.5% (n=10, N=16)		75% (n=12, N=16) Abnormal Tibial	
Total	22.58% (n=7, N=31) prolonged					61.29% (n=19, N=31), absent			83.87% (n=26, N31)	
H reflex in Tibial nerve	Absent					14			Absent in 93.33% n=14, N=15)	

Findings in AMAN (N=7) [Table 3]

CMAP was reduced in 92.85% (n= 26, N=28) of the total nerve studied, of which median and tibial nerves were affected in almost 100% (n=7) of nerves studied. The tibial nerve was seen as nonstimulable in 42.85% (n=3, N=7) and the peroneal nerve in 28.57 % (n=2, N=7) of the nerve studied. NCV was reduced in overall only 3.57% (n=1, N=28) of nerves studied. The F-wave response was absent in 57.1 % (n=4, N=7) of the median nerve and 71.4 % (n=5, N=7) of the tibial nerve, although the F-wave minimal latencies were normal throughout all remaining AMAN patients. The H- reflex was absent in 83.33 % of the patients (n=5, N=6).

Table 3: Findings in AMAN patient (N=7), LLN (Lower Limit of Normal), ULN (Upper limit of normal), n=numbers of Identified Abnormalities, N=total number studied, camp (compound motor action potential in millivolts)

Electrophysiological motor findings		Nerves studied				TOTAL (N=28)
		MEDIAN (N=7)	ULNAR (N=7)	PERONEAL (N=7)	TIBIAL (N=7)	
Percentage of decreased distal camp amplitude (millivolt) in cases < LLN		100% (n=7)	85.71% (n=6)	85.71% (n=6))	100% (n=7)	92.85% (n=26)
Percentage of non-stimulable nerve		14.28% (n=1)	0	28.57% (n=2)	42.85% (n=3)	21.42% (n=6)
Percentage of decreased NCV		0	0	14.28% (n=1)	0	3.57% (n=1)
F wave minimum latency in median & tibial nerve	Prolonged	0			0	0
Total	Absent	57.14% (n=4, N=7)			71.4% (n=5, N=7)	64.28% (n=9, N=14)
H-REFLEX (tibial nerve)	Absent	83.33% (n=5, N=6)				
	Present	16.67% (n=1, N=6)				

Finding during the first three days (N=13) [Table 4] [Figure 2]

A total of 13 cases were presented during 0-3 days of the illness. The ratio of males to females was 1.6:1. Prolonged motor distal latency was seen in overall 63.46% (n=33, N=52) of the nerve studied of which the median nerve was most involved in 76.92% (n=10, N=13), followed by the ulnar nerve and peroneal nerve each involved in 61.53% (n=8, N=13) of the nerve studied. Decreased CMAP amplitude was seen in overall 69.23% (n=36 N=52) of the total nerve studied, of which the tibial and ulnar nerve was most affected in 76.92% (n=10, N=13) of the nerves studied. Decreased motor NCV was seen in 48.07% (n=25, N=52) of the nerves studied and the most common to be involved was the median and ulnar nerves each in 61.53% (n=8, N=13) of the nerves studied.

Sensory nerve findings were less frequent in the first (0-3) days. Increased latency was seen in only 2.63% (n=1, N=38) and was found only in the median nerve in 7.69% (n=1, N=13), ulnar and sural nerve was spared and showed normal finding. Decreased sensory amplitude was seen in 18.42% (n=7, N=38) of nerves studied of which the sural nerve was most affected in 25% (n=3, N=12) of the nerves studied. Decreased NCV was seen in 7.89% (n=3, N=38) nerve studied and was most common in the sural nerve in 16.66% (n=2, N=12) nerve studied, the ulnar nerve was spared.

Overall F-wave was prolonged in 15.38% (n=4, N=26)) and was absent in 61.53% (n=16, N=26) constituting total abnormal F- wave in 76.92% (n=20, N=26) of the nerves studied. Median nerve minimum latency was increased in 23.07 % (n=3, N=13) and absent in 53.84% (n=7, N=13) nerve studied. Prolonged F wave minimum latency was observed in 7.69 % (n=1, N=13) of the tibial nerves tested, while it was absent in 69.23 % (n=9, N=13).

H- reflex was absent in 83.33% (n=10, N=12) of the nerve studied in cases.

Table 4: Finding during the first three days (N=13), LLN (lower limit of normal), ULN (upper limit of normal), n=numbers of identified abnormalities, N=total number studied M (motor) S (sensory)

Electrophysiological parameters altered (%)		Nerves studied (N=13)								Total percentage
		Median		Ulnar		Peroneal (M)	Tibial (M)	Sural (S), N=12	M (N=52)	S (N=38)
		M	S	M	S					
Distal latency in cases >ULN		76.92% (n=10)	7.69% (n=1)	61.53% (n=8)	0	61.53% (n=8)	53.84% (n=7)	0	63.46% (n=33)	2.63% (n=1)
Decreased distal compound action amplitude < LLN		53.84% (n=7)	15.38% (n=2)	76.92% (n=10)	15.38% (n=2)	69.23% (n=9)	76.92% (n=10)	25% (n=3)	69.23% (n=36)	18.42% (n=7)
Decreased NCV<LLN		61.53% (n=8)	7.69% (n=1)	46.15% (n=6)	0	61.53% (n=8)	23.07% (n=3)	16.66% (n=2)	48.07% (n=25)	7.89% (n=3)
F wave abnormality	Prolonged	23.07% (n=3)					7.69% (n=1)	15.38 % (n=4, N=26) prolonged		Total abnormal =76.92% (n=20)
	Absent	53.84% (n=7)					69.23% (n=9)	61.53 % absent (n=16, N=26)		
H-reflex finding (N=12)	Absent						10		83.33% (n=10, N=12}	
	Present						2			

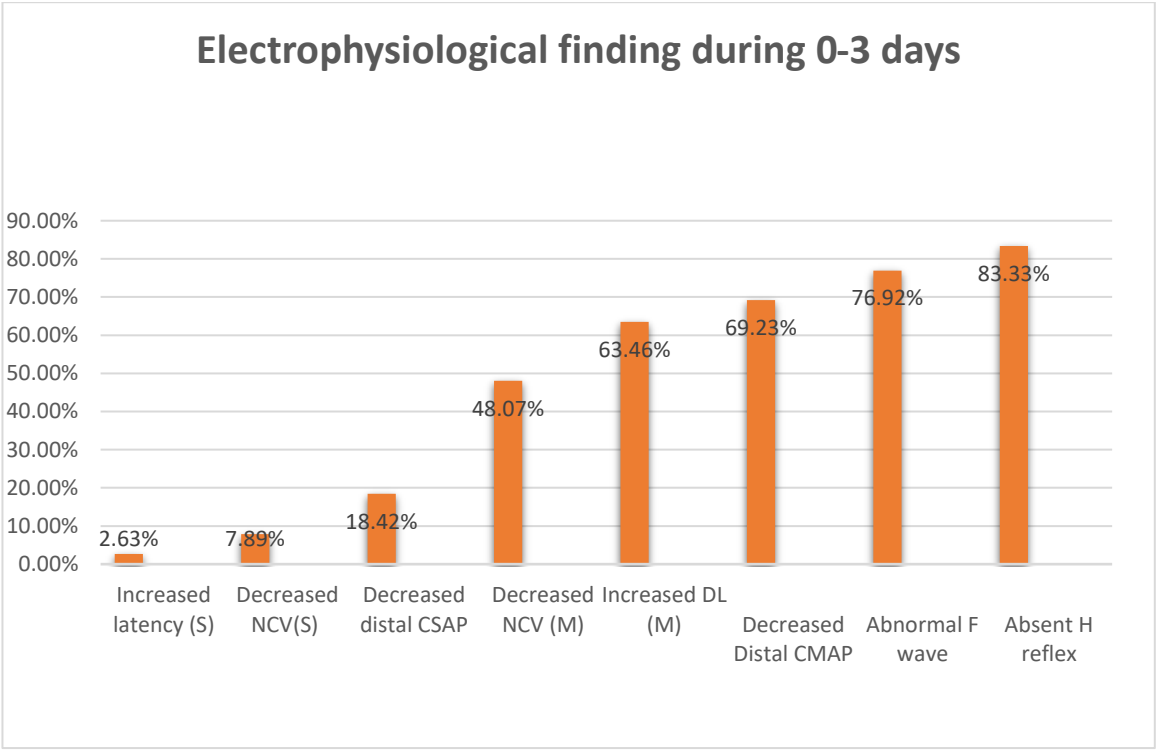

Figure 2: Relative percentage (in increasing order) of the electrophysiological abnormalities found during the first three days in the patients, sensory nerve findings were less frequent than the motor nerve finding in the first (0-3) days.

Discussion

Electrophysiological findings

Our normative data was overall comparable to the normative data of the Kalita and Mishra [9] and to the findings on 79 subjects conducted by Kimura.[14] There was no marked discrepancy between them.

The frequency distribution of GBS subtypes was similar to those obtained in previous investigations by Sharma Geetanjali et al [15] and Christiaan Fokke et al [16], in which AIDP was the most predominant variant.

Regarding findings in AIDP

Our findings on the H reflex and F waves in AIDP patients matched those of Paul H. Gordon et al. [17]. They discovered that among the early electrodiagnostic findings in GBS patients, the H reflex was non-existent in 30 (97%) of 31 patients and that the F wave was aberrant in 25 (84%) of cases. Similarly, Ranka Baraba et al. [18] found that 90.7% had no H reflex, and 65.2%–74.8% had delayed F wave latency. In 2014, Samira Yadegari et al [19] identified unobtainable H reflex as being the most prominent finding in AIDP and commented that it had a high sensitivity, but its specificity was limited because some of their patients with axonal GBS also had this trait. Prolonged F-wave latency was only detected in AIDP cases in their investigation. In line with this, our research found prolonged F wave minimum latency in only AIDP patients, with no cases of AMAN showing this feature.

In contrast, the North American GBS Investigation Group identified extended motor DL and delayed or absent F waves as the initial aberrant features [20,21], and Albers and colleagues [21] reported delayed and reduced CMAP amplitude as the initial deviation in their study. In

contrast, in our study, prolonged motor DL was not the most commonly affected variable; instead, we found abnormal F waves and absent H reflex as the most common findings, indicating that our findings differed from these studies in terms of the most common electrophysiological variable involved. This could be due to differences in laboratory settings and other local prevailing factors.

Findings in AMAN

Reduced CMAP amplitude was the most common finding in 92.85% of the AMAN patients in our study, which was consistent with McKhann GM et al's findings [22]in which substantial reductions in motor evoked amplitudes following distal stimulation were found in 22 of 36 patients (61.11 percent). The action potentials of the sensory nerves were normal. AMAN form of GBS was described clinically by acute paralysis without sensory involvement and electro diagnostically by low CMAP amplitudes, suggesting axonal injury, without signs of demyelination, in research by Ho TW et al. [23]. We found normal F wave minimum latency in the nerve, which was stimulable, corroborating the absence of demyelination in AMAN patients. These facts were also in concordance with various earlier literature by Anthony A. Amato [24] Van der Meche FG [25]

Findings in AMSAN

One patient in our study was grouped under AMSAN. There were axonal features in both motor and sensory nerves, the CMAP amplitude was reduced in the ulnar and peroneal nerve by more than 50% of LLN, and 85% reduced SNAP amplitude was seen in the sensory median nerve and sural nerve. Our NCS finding in AMSAN was in line with the finding elicited by Jocelyn Cheng et al. [25], Their research found that the limbs were affected by an axonal sensorimotor polyneuropathy.

Unexcitable

One patient was grouped under the unexcitable group as all the motor nerves studied were nonstimulable, the tibial and median F wave and H reflex were not identified in this patient. Our findings agreed with the Hadden RD et al.[11] In his study, based on the Motor Nerve Conduction criteria he categorized the GBS patients into five groups and observed 3% unexcitable cases.

Findings in (0-3) days

As per our study, the unobtainable/absent H-reflex was the commonest electrophysiological variable followed by abnormal F wave to be affected in the early (0-3) days of the illness. Also, on taking both F Wave and H-reflex it was seen that all the patients were having either of the abnormalities present. Sensory nerves were lesser involved, variation of sensory distal latency in the median and ulnar nerves and conduction velocity in ulnar nerves was statistically insignificant ($p > .05$).

Our findings were in line with Gordon PH et al, [17] with respect to F wave and H Reflex, where they did not observe any H reflex in 97% and abnormal F wave was seen in 84% of cases.

Conclusion

The electrophysiological finding of 30 GBS patients in reference to 30 normal controls were studied. AIDP was the most common variant in 53.33% of the cases, followed by AMAN in 23.33%, AMSAN 1 (3.33%), unexcitable 1(3.33%), and equivocal in 16.67%. Motor electrophysiological parameters showed significant alteration with a p-value of $<.05$ in early diagnosed cases; in contrast, sensory nerve findings were less frequent in the first (0-3) days.

Of all the variables, H-reflex was the earliest variant to be affected, followed by the F-wave in the cases during 0-3 days of illness. So based on our study, we recommend the inclusion of H-reflex and F- wave as a routine test in the patients suspected of GBS, as it holds a promise to increase the sensitivity of early case detection and its subclassification, leading to prompt and speedy intervention with a potential to improve the overall prognosis.

Acknowledgment
We would like to express our gratitude to all the patients and controls who took part in the study.

Informed consent declaration
The authors certify that all proper written and informed consent was received from the relatives of the patients and controls in the study.

Sponsorship and financial support
Nil

Interest Conflicts
There are no competing interests declared by the authors.

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