Study of various motor conduction properties – Distal motor latency (DML), Compound muscle action potential (CMAP) and nerve conduction velocity (NCV) in common peroneal nerve (CPN) in the patients after first time stroke

Dr Trupti Keshaorao Patil[1], Dr Sadanand Dashrath Kamble[2]

[1]Assistant Professor, Department of Medicine, Vilasrao Deshmukh Government Medical College, Latur, INDIA.
[2]Assistant Professor, Department of Medicine, Vilasrao Deshmukh Government Medical College, Latur, INDIA.

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Abstract:
Background: This study investigates the impact of a first-time stroke on motor conduction properties, specifically focusing on Distal Motor Latency (DML), Compound Muscle Action Potential (CMAP), and Nerve Conduction Velocity (NCV) in the Common Peroneal Nerve (CPN). Understanding these parameters post-stroke is crucial for developing targeted rehabilitation strategies. **Objectives:** The primary objective was to assess the changes in DML, CMAP, and NCV in the CPN of patients who have experienced their first stroke. The study aimed to correlate these changes with the severity and recovery potential of motor deficits. **Methods:** A total of 250 patients, who had experienced their first stroke, were recruited. Standardized techniques were used to measure DML, CMAP, and NCV in the CPN. The assessments were conducted within the first week post-stroke and repeated after three months. Data analysis involved comparing the initial and follow-up measures, employing statistical methods to evaluate the significance of changes over time. **Results:** The study found significant alterations in DML, CMAP, and NCV in stroke patients compared to normal values. There was a notable correlation between the severity of motor deficit and the degree of change in these parameters. Patients exhibiting greater changes in DML, CMAP, and NCV tended to have more severe motor impairments. **Conclusion:** This study underscores the importance of assessing motor conduction properties in stroke patients. The changes in DML, CMAP, and NCV in the CPN post-stroke provide valuable insights into the nature and extent of motor impairment, which can guide more effective rehabilitation strategies.
Keywords: Stroke, Common Peroneal Nerve, Motor Conduction, Distal Motor Latency, Compound Muscle Action Potential, Nerve Conduction Velocity.

Corresponding Author: Dr Sadanand Dashrath Kamble, Assistant Professor, Department of Medicine, Vilasrao Deshmukh Government Medical College, Latur, INDIA.

Introduction:

Stroke is a leading cause of disability worldwide, often resulting in motor deficits due to neurological impairments. Understanding the pathophysiological changes in motor conduction properties following a stroke is pivotal for developing effective rehabilitation strategies. The Common Peroneal Nerve (CPN) is frequently affected in stroke patients, impacting lower limb function. This study focuses on evaluating key motor conduction properties – Distal Motor Latency (DML), Compound Muscle Action Potential (CMAP), and Nerve Conduction Velocity (NCV) – in the CPN of patients after their first stroke.

Motor conduction studies, including measurements of DML, CMAP, and NCV, are essential tools in neurophysiology. They provide valuable insights into the functioning of peripheral nerves and motor pathways, which are often compromised after a stroke [1]. DML is a critical parameter that reflects the conduction time in the distal segment of the nerve and is indicative of demyelination or axonal damage [2]. CMAP, representing the electrical response of a muscle following nerve stimulation, gives an overview of the health of the motor units [3]. NCV, the speed at which an electrical impulse travels along the nerve, can indicate the presence and extent of nerve damage [4].

Recent studies have shown that alterations in these conduction properties can serve as biomarkers for the extent of neural damage and potential for recovery in stroke patients [5]. Moreover, the assessment of these parameters in the CPN is particularly significant due to its role in lower limb motor control, a key aspect in the rehabilitation of stroke patients [6].

Aim:

To provide a comprehensive analysis of DML, CMAP, and NCV in the CPN post-stroke, offering insights into their clinical relevance in stroke recovery.

Objectives:

1. To assess Motor Conduction Properties Post-Stroke.
2. To correlate with Clinical Manifestations of Stroke.

Material and Methodology:

Study Design: This study is a prospective observational study conducted over a period of 12 months. The objective is to evaluate the DML, CMAP, and NCV in the CPN of stroke patients.

Sample Size: A total of 250 patients who experienced their first-time stroke were included in the study. The sample size was determined based on previous literature and power analysis to ensure sufficient statistical power for detecting significant differences in motor conduction properties.

Inclusion Criteria:

1. Adults aged 18 years or older.
2. Diagnosed with a first-time stroke confirmed by neuroimaging (CT/MRI).
3. Stroke occurrence within the last 1 month.

Exclusion Criteria:

1. History of any neurological or musculoskeletal disorder affecting the lower limbs prior to the stroke.
2. Severe cognitive impairment or communication barriers.
3. Presence of any contraindication to nerve conduction studies (e.g., pacemaker).

Data Collection: Demographic data: age, gender, and stroke risk factors. Clinical data: type and severity of stroke, affected hemisphere, and functional impairment level.

Motor Conduction Study Protocol: Measurements were taken for DML, CMAP, and NCV in the CPN using standard electromyography (EMG) equipment. Baseline measurements were conducted within the first week post-stroke, with follow-up measurements at 1, 3, and 6 months.

The procedure was performed by experienced neurophysiologists, adhering to established guidelines for nerve conduction studies.

Statistical Analysis: Descriptive statistics were used to summarize demographic and clinical characteristics. Correlation analysis was conducted to explore the relationship between motor conduction properties and clinical parameters of stroke severity. Statistical significance was set at $p<0.05$.

Ethical Considerations: The study protocol was approved by the Institutional Review Board (IRB). Written informed consent was obtained from all participants or their legal guardians. The study adhered to the principles of the Declaration of Helsinki for research involving human subjects.

Observation and Results:

Table 1: Comparative Analysis of Motor Conduction Parameters in Patients Post-First-Time Stroke: Distal Motor Latency (DML), Compound Muscle Action Potential (CMAP), and Nerve Conduction Velocity (NCV) with Statistical Significance

Parameter	Normal Range	Post-Stroke Mean (±SD)	Odds Ratio (OR)	95% CI for OR	P-value
DML (ms)	2.0 - 4.5	5.3 (±1.2)	1.8	1.2 - 2.7	0.004
CMAP (mV)	5.0 - 10.0	3.2 (±0.8)	2.1	1.4 - 3.1	<0.001
NCV (m/s)	40 - 60	35 (±5)	1.6	1.1 - 2.3	0.01

Table 1 presents a comparative analysis of motor conduction parameters in patients after experiencing their first stroke, focusing on Distal Motor Latency (DML), Compound Muscle Action Potential (CMAP), and Nerve Conduction Velocity (NCV). It shows that post-stroke, there are significant deviations from the normal ranges in these parameters. The DML increased to 5.3 ms (normal range: 2.0 - 4.5 ms), with an Odds Ratio (OR) of 1.8, indicating a higher likelihood of increased latency post-stroke. CMAP values decreased to 3.2 mV (normal range: 5.0 - 10.0 mV), with an OR of 2.1, suggesting a significant reduction in muscle response. NCV decreased to 35 m/s (normal range: 40 - 60 m/s), with an OR of 1.6. All these changes were statistically significant, as indicated by the P-values (DML: 0.004, CMAP: <0.001, NCV: 0.01), highlighting the profound impact of stroke on motor nerve conduction.

Table 2: Correlation between Clinical Manifestations of Stroke and Motor Conduction Parameters: Analysis of Stroke Severity, Functional Mobility, and Motor Impairment with DML, CMAP, and NCV

Clinical Manifestation	Correlated Parameter	r (Pearson Correlation Coefficient)	95% CI for r	P-value
Stroke Severity (NIHSS Score)	DML (ms)	-0.45	-0.55 to -0.33	<0.001
Functional Mobility (FMA Score)	CMAP (mV)	0.52	0.41 to 0.62	<0.001
Motor Impairment (MRC Scale)	NCV (m/s)	0.38	0.27 to 0.48	0.003

Table 2 illustrates the correlations between various clinical manifestations of stroke and motor conduction parameters, namely Distal Motor Latency (DML), Compound Muscle Action Potential (CMAP), and Nerve Conduction Velocity (NCV). A significant negative correlation (r =

-0.45) was found between stroke severity, as measured by the NIHSS score, and DML, suggesting that higher stroke severity is associated with increased DML. Functional mobility, assessed by the FMA score, showed a positive correlation with CMAP (r = 0.52), indicating that better functional mobility is associated with higher CMAP values. Additionally, motor impairment, measured by the MRC Scale, demonstrated a positive correlation with NCV (r = 0.38). All these correlations were statistically significant, as indicated by their P-values, revealing insightful associations between clinical stroke outcomes and changes in motor conduction properties.

Discussion:

The findings in Table 1, showing significant changes in Distal Motor Latency (DML), Compound Muscle Action Potential (CMAP), and Nerve Conduction Velocity (NCV) in patients post-first-time stroke, align with and contribute to the existing body of research on neurophysiological changes following a stroke.

The increase in DML post-stroke (mean 5.3 ms) compared to the normal range (2.0 - 4.5 ms) with an OR of 1.8 is consistent with the findings of Hahn AF et al.(2022) [1], who reported delayed motor responses in stroke patients, likely due to demyelination or axonal damage. This is statistically significant (P = 0.004), suggesting a reliable alteration due to stroke.

The decrease in CMAP (mean 3.2 mV) from the normal range (5.0 - 10.0 mV) with an OR of 2.1, and its high significance (P < 0.001), resonates with Poglio F et al.(2022) [2], which demonstrated reduced muscle response amplitude in stroke patients. This reduction can be attributed to the loss of motor units and altered synaptic efficacy post-stroke.

The findings on NCV (mean 35 m/s) showing a decrease from the normal range (40 - 60 m/s) with an OR of 1.6 and a P-value of 0.01, align with Dimitrova A et al.(2022) [3]. They highlighted that stroke can lead to slowed nerve conduction, possibly due to nerve fiber damage or altered ion channel function.

Overall, these results underscore the significant impact of stroke on motor nerve conduction, providing insights into the extent of neural impairment. They also reinforce the idea proposed by Ghiglione E et al.(2022) [4], which suggests motor conduction studies could be integral in assessing the severity of neural damage post-stroke and in planning rehabilitation strategies.

Table 2 highlights the correlation between clinical manifestations of stroke and motor conduction parameters, including Distal Motor Latency (DML), Compound Muscle Action Potential (CMAP), and Nerve Conduction Velocity (NCV). These correlations provide valuable insights into the impact of stroke on neuromuscular function and its clinical manifestations.

The negative correlation between stroke severity (NIHSS Score) and DML (-0.45) aligns with the findings of Ciaramitaro P et al.(2022) [5], who noted that more severe strokes often result in greater neural damage, reflected in increased DML. The statistical significance (P < 0.001) emphasizes the reliability of this correlation.

The positive correlation between functional mobility (FMA Score) and CMAP (0.52) is consistent with Borgna M et al.(2022) [6]. They reported that better functional outcomes in stroke patients are often associated with higher CMAP values, indicating healthier motor unit function. This correlation's statistical significance (P < 0.001) underscores its clinical importance.

Lastly, the positive correlation between motor impairment (MRC Scale) and NCV (0.38) is supported by Osio M et al.(2022) [7]. They found that less motor impairment in stroke patients typically coincides with better nerve conduction velocities, suggesting less neural damage. The P-value of 0.003 indicates a significant correlation.

These correlations reinforce the notion that motor conduction parameters can provide essential insights into the clinical outcomes of stroke, as suggested by Porfiri L et al.(2022) [8]. They underscore the importance of neurophysiological assessments in understanding and predicting recovery and rehabilitation needs in stroke patients.

Conclusion:

This study has provided significant insights into the alterations in motor conduction properties, specifically DML, CMAP, and NCV, in the CPN of patients following their first stroke. The findings reveal that stroke has a profound impact on these neurophysiological parameters, indicating alterations in nerve conduction and muscle response post-stroke. The increased DML and decreased CMAP and NCV in stroke patients compared to the normal ranges suggest that strokes can cause considerable neural and muscular dysfunction.

Moreover, the correlations established between these altered conduction properties and clinical manifestations of stroke, such as severity, functional mobility, and motor impairment, underscore the potential of these neurophysiological measures in assessing and predicting the outcomes of stroke rehabilitation. The study's results emphasize the importance of early and comprehensive neurophysiological assessments in stroke patients, which could guide personalized rehabilitation strategies and potentially improve recovery outcomes.

In conclusion, this study contributes valuable knowledge to the understanding of post-stroke neuromuscular alterations. It highlights the importance of integrating motor conduction studies in the clinical evaluation and management of stroke patients, paving the way for more targeted and effective rehabilitation approaches. Further research in this area could focus on exploring longitudinal changes in these parameters and their relationship with long-term recovery and functional outcomes in stroke survivors.

Limitations of Study:

1. **Sample Diversity and Size:** The study focused on a specific group of patients (those who experienced their first-time stroke), which may limit the generalizability of the findings to all stroke patients. Additionally, the sample size of 250 patients, while adequate, might not fully capture the variability in stroke presentations and outcomes.
2. **Single Time-Point Measurements:** The assessments of DML, CMAP, and NCV were conducted at specific time points post-stroke. This approach might not fully account for the dynamic nature of neurological recovery and changes in motor conduction properties over time.
3. **Lack of Longitudinal Follow-Up:** The study lacked a longitudinal follow-up to assess the long-term changes in motor conduction properties and their impact on patient outcomes. Long-term follow-up could provide more comprehensive insights into the recovery process and the lasting effects of stroke.
4. **Potential Confounding Variables:** While efforts were made to control for confounding factors, there could be other variables such as medication, rehabilitation therapies, and individual patient characteristics (like comorbidities) that might have influenced the results.
5. **Subjectivity in Clinical Assessment:** The clinical assessments used to measure stroke severity, functional mobility, and motor impairment are subject to some degree of

subjectivity, which could affect the precision of the correlations with motor conduction properties.

6. **Technique and Equipment Variability:** Variations in the techniques and equipment used for measuring DML, CMAP, and NCV could introduce some inconsistencies in the data.

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