Observational Study

# Correlation Between Electromyography and Severity and Prognosis of Upper Limb Herpes Zoster

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**Background:** There are differences in the clinical treatment schemes for patients with different severities of herpes zoster (HZ). Therefore, effective and accurate evaluation of disease severity is of great significance for the formulation of treatment plans. Postherpetic neuralgia (PHN) with long-term chronic pain leads to anxiety, depression, and even suicidal thoughts, which place a heavy burden on society and the family. Therefore, identifying risk factors and taking early intervention to reduce the occurrence of PHN is meaningful. Electromyography (EMG) can provide technical support for the early diagnosis of peripheral neuropathy. However, the application of EMG in HZ and PHN has rarely been reported. The purpose of this study was to compare the detection indices of EMG in patients with different severities and prognoses of HZ and to analyze the application of EMG in severity and prognosis of HZ.

**Objective:** This study aimed to explore the relationship between EMG and severity and prognosis of upper limb HZ.

**Study Design:** A retrospective, observational study.

**Setting:** The study was carried out in the Pain Department of the affiliated Hospital of Jiaxing College in Jiaxing, China.

**Methods:** A total of 91 patients with upper limb HZ at the First Hospital of Jiaxing between January 2015 and August 2021 were enrolled. The patients were divided into mild, moderate, and severe HZ groups according to their numeric rating scale (NRS) scores. The occurrence of PHN was defined as a poor prognosis. The patients were divided into non-PHN and PHN groups according to the occurrence of PHN. Motor and sensory conduction indices of the median nerve were measured in each group. Spearman's correlation analysis was used to analyze the relationship between the EMG-related data of the median nerve and the NRS score and muscle strength. Univariate and multivariate logistic regression analyses were used to determine the independent influencing factors of PHN in patients with upper limb HZ, and the receiver operating characteristic (ROC) curve was drawn to evaluate the predictive value of EMG-related data in patients with upper limb HZ.

**Results:** Among 91 patients, there were 29 patients in the mild HZ group, 31 in the moderate HZ group, and 31 in the severe HZ group. The sensory nerve action potential (SNAP) amplitude of the median nerve in the severe and moderate HZ groups was lower than that in the mild HZ group, and that in the severe HZ group was lower than that in the moderate HZ group ($F = 22.192$, $P < 0.05$). Through Spearman's correlation analysis, it was found that the compound muscle action potential (CMAP) and SNAP amplitudes of the median nerve on the affected limb were negatively correlated with the NRS score ($r = –0.266$, $P = 0.011$; $r = –0.778$, $P < 0.001$), and there was no significant correlation between each index and muscle strength ($P > 0.05$). Among 91 patients, 44 and 47 were in the non-PHN and PHN groups, respectively. Univariate and multivariate logistic regression analyses showed that the CMAP amplitude of the median nerve on the affected limb (OR = 0.241, 95% CI: 0.098-0.567, $P = 0.001$) and SNAP amplitude (OR = 0.268, 95% CI: 0.110-0.628, $P = 0.002$) were independent influencing factors of PHN. Through the analysis of the ROC curve, it was found that the CMAP and SNAP amplitudes of the median nerve on the affected limb had a high predictive value for PHN (AUC = 0.657, $P = 0.010$; AUC = 0.773, $P < 0.001$). The cutoff values were

5.45 mV and 10.80 mV, respectively; and the predictive value of the 2 indices combined was the highest (AUC = 0.785, $P < 0.001$).

**Limitations:** The nonrandomized, single-center, small sample size, and retrospective design are major limitations of this study.

**Conclusion:** The CMAP and SNAP amplitudes of the median nerve on the affected limb were related to the degree of pain in patients with upper limb HZ. The CMAP and SNAP amplitudes of the median nerve on the affected limb can be used as prognostic factors for patients with upper limb HZ, and CMAP amplitude combined with SNAP amplitude is more valuable in predicting prognosis.

**Key words:** Electromyography, herpes zoster, postherpetic neuralgia

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Herpes zoster (HZ) is caused by reactivation of varicella-zoster virus latent in the sensory ganglia (1). It often invades the unilateral nerve segment, which is mainly characterized by severe pain accompanied by clustered herpes on the skin of the corresponding segment (2-4). The chest and back are the areas most frequently affected by HZ, accounting for approximately 50% and 70% of the total number of cases, respectively (5). However, HZ in the limb is relatively rare in the clinic, and this special form of HZ may have complications, such as decreased muscle strength and motor dysfunction (6).

Postherpetic neuralgia (PHN) refers to pain in the herpetic area that lasts for more than 3 months after the cutaneous herpes subsides or scabs caused by the varicella-zoster virus (7). It is a serious complication caused by viral infections. Approximately 10 to 25% of patients experience pain that lasts for more than one year. Long-term chronic pain leads to anxiety, depression, and even suicidal thoughts, which place a heavy burden on society and the family. Many studies have shown that PHN is more common in patients over 50 years of age, with low immunity and complicated chronic diseases, a wide range of acute skin lesions, and severe pain (8).

Electromyography (EMG) is an electrophysiological detection method that has been widely used in recent years to record muscle bioelectric patterns in detail and evaluate the injury according to the formed electromyographic condition (9,10). Thus, the functional status of nerves, muscles, and neuromuscular junctions can be inferred, which can provide accurate and objective advantages. EMG can provide technical support for the early diagnosis of peripheral neuropathy. Thus, it plays an important role in the diagnosis and treatment of peripheral neuropathy, such as peripheral nerve entrapment syndrome and lumbar disc herniation (11). However, the application of EMG in HZ and PHN has rarely been reported. The purpose of this study was to compare the detection indices of EMG in patients with different severities and prognoses of HZ and to analyze the application of EMG in severity and prognosis of HZ.

## Methods

### Patients

A total of 91 patients with upper limb HZ at the First Hospital of Jiaxing between January 2015 and August 2021 were enrolled. The process for patient selection is presented in Fig. 1. Patients were divided into mild, moderate, and severe HZ groups according to their NRS scores (NRS ≤ 3, mild group; 3 < NRS ≤ 6, moderate group; and NRS > 6, severe group).

Inclusion criteria: 1) fit the diagnostic criteria of herpes zoster; 2) herpes zoster is located in the upper limb; 3) 25-85 years old; 4) the course of disease is less than 3 months.

Exclusion criteria: 1) had history of limb peripheral nerve trauma or upper limb operation; 2) Merge diseases that can cause spinal cord or peripheral nerve damage such as spondylosis, diabetes, peripheral nerve entrapment syndrome; 3) blood biochemical examination indicates existence or suspected myogenic damage; 4) refusal to follow up or provide clinical data.

### Observation Indicators

General demographic data were recorded, including gender, age, lesion location, course of disease, lesion area, whether they had an immune system disease, the NRS score, muscle strength, and EMG indices.

The lesion area was assessed relative to the palm area of the patient; the palm area accounted for 1%, and the lesion size was divided into small areas of ≤ 5% and large areas of > 5%. UK Medical Research Council (MRC) scores were used to measure muscle strength: 0, no muscle contraction; 1, muscle contraction but no joint activity; 2, full range movement of the joint under no gravity; 3, full range of movement of the joint under

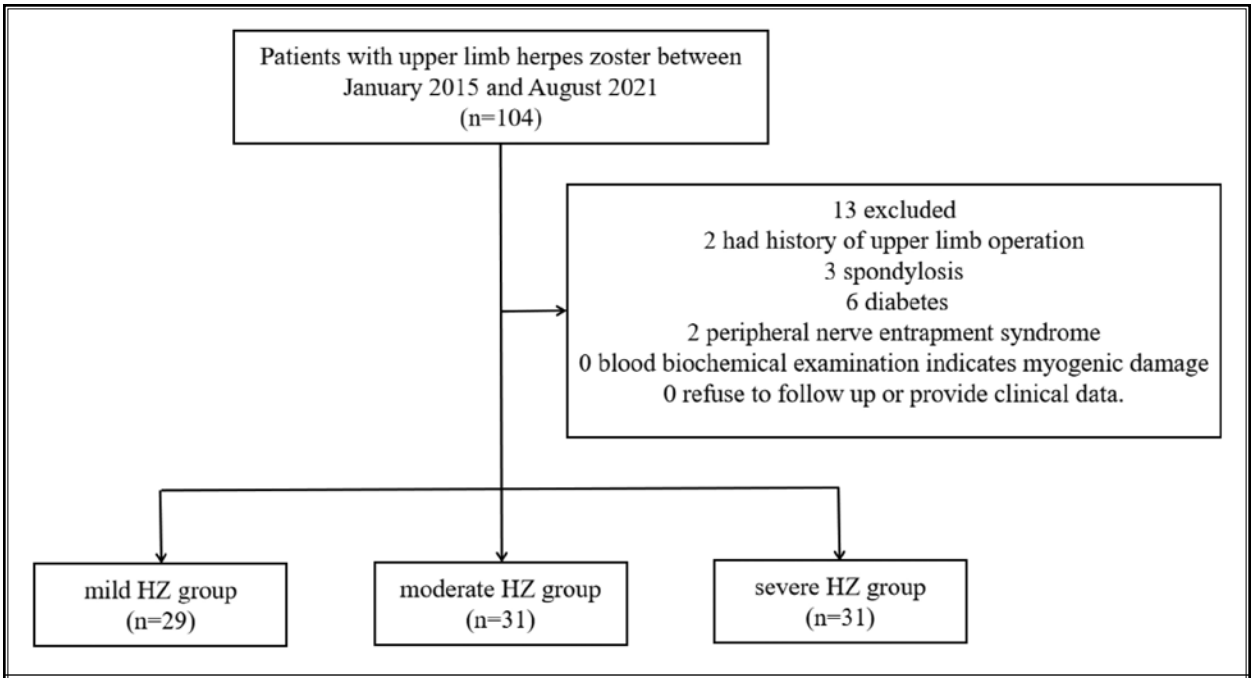


Fig. 1. *Flow of patients through this retrospective study. Ultimately, 91 patients were enrolled who suffer from upper limb herpes zoster.*

an anti-gravity state; 4, joint can resist partial resistance activity, but worse than normal; and 5, normal muscle strength, that is, the joint can resist the full range of movement under maximum resistance. EMG indices were measured in the median nerve; motor nerve indices included distal motor latency (DML), compound muscle action potential (CMAP) amplitude, and motor nerve conduction velocity (MNCV); sensory nerve indices included distal sensory latency (DSL), sensory nerve action potential (SNAP) amplitude, and sensory nerve conduction velocity (SNCV).

## EMG Procedure

In a quiet room maintained at a temperature of 22 to 24°C, the skin temperature was checked to be higher than 32°C, and the skin surface was cleaned. A Keypoint electromyography/evoked potential instrument (Dantce Medical Company, Denmark) was used for measurements. The evaluations were performed by the same doctor who had received professional training and obtained relevant qualifications.

In the motor nerve conduction assessment, a saddle electrode was used as the stimulation electrode, a surface electrode as the recording and reference electrodes, and the ground wire was placed between the stimulation and recording electrodes. Patients were placed in a supine position, the recording electrodes for the median nerve were placed on the belly of the abductor pollicis brevis, and the stimulation electrodes were placed at the wrist and elbow. DML and CMAP amplitudes were recorded after wrist stimulation, and MNCV was calculated using elbow and wrist stimulation. When evaluating motor nerve conduction, the intensity of electrical stimulation was gradually increased until the CMAP amplitude, which was defined as the distance between the baseline and peak of the negative wave, reached a maximum.

Sensory nerve conduction assessment was performed in both upper limbs using the reverse recording method. A saddle electrode was used as the stimulation electrode, and ring and surface electrodes were used as the recording and reference electrodes, respectively. The DSL, SNAP amplitude, and SNCV of the bilateral median nerves were recorded. The median nerve was recorded with a circular electrode, the recording electrode was placed on the proximal interphalangeal joint of the middle finger, the reference electrode was placed on the distal interphalangeal joint, and the stimulation electrode was placed on the median nerve of the wrist. During the evaluation of sensory nerve conduction, the stimulation intensity was gradually increased until the waveform baseline was stable. When the amplitude

of the wave was at its highest, waveforms were superimposed 30 times. The amplitude was defined as the distance from the baseline to the negative peak, and the conduction velocity was the distance between the stimulation electrode and recording electrode divided by the latency.

### Follow-up

After discharge, the patients were followed-up once per month for 3 months. At 3 months, according to the occurrence of PHN, the patients were divided into non-PHN and PHN groups, and the occurrence of PHN was defined as a poor prognosis.

### Statistical Analysis

Statistical analyses were performed using SPSS software version 26.0 (IBM Corporation, Armonk, NY). All data were tested for normality using the Shapiro-Wilk test and histograms. Normally distributed continuous data are presented as mean ± SD, non-normally distributed continuous data are presented as medians and interquartile ranges (IQRs), and categorical data are presented as numbers and percentages (%). Variance analysis was used for comparisons among groups, and the LSD t-test was used for post-hoc analysis. Independent t-tests were used to compare normally distributed continuous data, Mann-Whitney U tests were used for non-normally distributed continuous data, and chi-squared tests were used for categorical data. Spearman's correlation analysis was used to analyze the correlation between EMG-related data and the NRS scores and muscle strength in patients with upper limb HZ. The EMG-related data were included in the univariate analysis, and independent variables ($P < 0.05$) were included in the multivariate logistic regression analysis. Multivariate logistic regression analysis was used to analyze the independent influencing factors of PHN in upper limb HZ. The value of EMG-related data in predicting the occurrence of PHN in patients with upper limb HZ was evaluated using the receiver operating characteristic (ROC) curve, and the area under the curve (AUC) was calculated. Statistical significance was set at $P < 0.05$.

## Results

### Demographic Data of Groups by Severity

Comparing the demographic data of the 3 groups, the NRS scores in the severe and moderate HZ groups were higher than those in the mild HZ group; the severe HZ group had higher scores than those in the moderate HZ group, and the difference was statistically significant (F = 81.513, $P < 0.05$). There was no significant difference in gender, age, lesion location, course of disease, lesion area, whether patients had immune system disease, or muscle strength between the 3 groups ($P > 0.05$). The details are listed in Table 1.

### EMG-Related Data of Groups by Severity

Compared to the healthy side, the CMAP amplitudes of the median nerve on the affected side in the 3 groups were significantly lower (t = 2.419, $P = 0.022$; t = 2.498, $P = 0.018$; t = 3.335, $P = 0.002$). However, there was no significant difference in DML or MNCV between the 2 sides ($P > 0.05$). The CMAP amplitude of the median nerve in the severe and moderate HZ group was lower than that in the mild HZ group, and the amplitude in the severe HZ group was lower than that in the moderate group, but the difference was not statistically significant (F = 2.406, $P = 0.096$). The details are listed in Table 2.

Compared to the healthy side, the SNAP amplitudes of the median nerve on the affected side in the 3 groups were significantly lower (t = 2.270, $P = 0.031$; t = 3.334, $P = 0.002$; t = 6.151, $P < 0.001$). However, there was no significant difference in DSL or SNCV between the 2 sides ($P > 0.05$). The SNAP amplitude of the median nerve in the severe and moderate HZ group was lower than that in the mild HZ group, and the amplitude in the severe HZ group was lower than that in the moderate group; the difference was statistically significant (F = 22.192, $P < 0.05$). The details are listed in Table 2.

### Spearman's Correlation Analysis

CMAP and SNAP amplitudes negatively correlated with the NRS score (r = –0.266, $P = 0.011$; r = –0.778, $P < 0.001$). There was no significant correlation between the other indices and the NRS score ($P > 0.05$). There was no significant correlation between muscle strength and any of the indices ($P > 0.05$). The details are listed in Table 3.

### Demographic Data of Groups by PHN Status

The NRS score of the PHN group was significantly higher than that of the non-PHN group (Z = 3.263, $P = 0.001$). There was no significant difference in gender, age, lesion location, course of disease, lesion area, whether they had immune system disease, or muscle strength between the 2 groups ($P > 0.05$). The details are listed in Table 4.

## EMG-Related Data of Groups by PHN Status

Comparing the EMG-related data of the affected side between the 2 groups, the CMAP and SNAP amplitudes in the PHN group were significantly lower than those in the non-PHN group (t = 2.970, $P = 0.005$; t = 5.473, $P < 0.001$). There were no significant differences in the other indices ($P > 0.05$). The details are listed in Table 5.

## Univariate and Multivariate Logistic Regression Analysis

Whether PHN occurred was used as the dependent variable (0 = non-PHN, 1 = PHN). The independent variables were meaningful, including the DML, CMAP amplitude, MNCV, DSL, SNAP amplitude, and SNCV. The median of patients with PHN and non-PHN of DML, CMAP amplitude, MNCV, DSL, SNAP amplitude, and SNCV were 7.27, 5.70, 54.20, 2.25, 9.10, and 54.20, respectively. According to the median of the above continuous variables, they were divided into 2 groups: the Up Group and the Down Group.

The results of the univariate analysis showed that CMAP amplitude and SNAP amplitude were factors related to PHN in patients with upper limb HZ ($P < 0.05$). DML, MNCV, DSL, and SNCV were not related to PHN in upper limb HZ ($P > 0.05$). The details are listed in Table 6.

Multivariate logistic regression analysis considered the occurrence of PHN as a dependent variable and factors with $P < 0.05$ in univariate analyses as independent variables. Multivariate logistic regression was performed using a step-by-step method. The results showed that CMAP amplitude (OR = 0.241, 95%

Table 1. *Demographic data of the mild, moderate, and severe HZ groups.*

| | Mild (n = 29) | Moderate (n = 31) | Severe (n = 31) | F/x² | *P* |
|---|---|---|---|---|---|
| Gender | | | | 1.632 | 0.442 |
| Male | 15 (51.72%) | 14 (45.16%) | 11 (35.48%) | | |
| Female | 14 (48.28%) | 17 (54.84%) | 20 (64.52%) | | |
| Age | 63.45 ± 15.43 | 66.32 ± 11.20 | 62.87 ± 8.73 | 0.729 | 0.485 |
| Lesion location | | | | 0.001 | 1.000 |
| Left | 13 (44.83%) | 14 (45.16%) | 14 (45.16%) | | |
| Right | 16 (55.17%) | 17 (54.84%) | 17 (54.84%) | | |
| Course of disease | 21.66 ± 17.47 | 29.97 ± 19.74 | 26.03 ± 21.71 | 1.326 | 0.271 |
| Lesion area | | | | 0.258 | 0.879 |
| ≤ 5% | 14 (48.28%) | 16 (51.61%) | 17 (54.84%) | | |
| > 5% | 15 (51.72%) | 15 (48.39%) | 14 (45.16%) | | |
| Immune system disease | | | | 0.336 | 0.845 |
| Yes | 8 (27.59%) | 8 (25.81%) | 10 (32.26%) | | |
| No | 21 (72.41%) | 23 (74.19%) | 21 (67.74%) | | |
| The NRS score | 2.00,1.00 | 5.00,2.00 | 8.00,1.00 | 81.513 | 0.000 |
| Muscle strength | 5.00,0.00 | 5.00,0.00 | 5.00,0.00 | 0.193 | 0.908 |

Results are expressed as mean ± SD, percentages, or as medians, IQR.
HZ, herpes zoster; NRS, numeric rating scales.

Table 2. *Comparison of EMG-related data of both upper limbs in the mild, moderate, and severe HZ groups.*

| | | Mild (n = 29) | Moderate (n = 31) | Severe (n = 31) | F | *P* |
|---|---|---|---|---|---|---|
| Healthy side | DML | 7.06 ± 1.45 | 7.77 ± 1.62 | 6.76 ± 2.38 | 2.350 | 0.101 |
| | CMAP | 7.58 ± 1.91 | 6.27 ± 2.19 | 6.81 ± 2.30 | 2.830 | 0.064 |
| | MNCV | 55.19 ± 4.33 | 53.63 ± 4.03 | 54.23 ± 5.51 | 0.843 | 0.434 |
| | DSL | 2.22 ± 0.42 | 2.29 ± 0.41 | 2.14 ± 0.44 | 0.913 | 0.405 |
| | SNAP | 17.86 ± 7.16 | 14.54 ± 7.39 | 13.98 ± 7.35 | 2.441 | 0.093 |
| | SNCV | 53.40 ± 15.81 | 53.35 ± 15.69 | 55.45 ± 4.81 | 0.257 | 0.774 |
| Affected side | DML | 6.93 ± 1.04 | 7.94 ± 1.45 | 7.92 ± 2.56 | 3.008 | 0.054 |
| | CMAP | 6.37 ± 2.37[a] | 5.33 ± 2.32[a] | 5.15 ± 2.24[a] | 2.406 | 0.096 |
| | MNCV | 54.20 ± 4.60 | 51.98 ± 6.90 | 54.80 ± 6.15 | 1.895 | 0.156 |
| | DSL | 2.16 ± 0.52 | 2.30 ± 0.42 | 2.23 ± 0.69 | 0.500 | 0.608 |
| | SNAP | 13.92 ± 6.95[b] | 9.41 ± 4.56[b] | 5.20 ± 3.06[b] | 22.192 | 0.000 |
| | SNCV | 53.26 ± 15.74 | 52.37 ± 16.30 | 54.17 ± 5.75 | 0.139 | 0.870 |

EMG, Electromyography; HZ, herpes zoster; DML, distal motor latency; CMAP, compound muscle action potential; MNCV, motor nerve conduction velocity; DSL, distal sensory latency; SNAP, sensory nerve action potential; SNCV, sensory nerve conduction velocity.
Note: Compared with the CMAP amplitude of healthy side, [a]$P < 0.05$; Compared with the SNAP amplitude of healthy side, [b]$P < 0.05$.

Table 3. *Correlation between EMG-related data of affected side and the NRS score and muscle strength.*

| | The NRS score | | Muscle strength | |
|---|---|---|---|---|
| | r | *P* | r | *P* |
| DML | 0.195 | 0.064 | -0.066 | 0.533 |
| CMAP | -0.266 | 0.011 | -0.123 | 0.246 |
| MNCV | -0.052 | 0.625 | 0.112 | 0.291 |
| DSL | 0.044 | 0.680 | 0.066 | 0.531 |
| SNAP | -0.778 | 0.000 | -0.065 | 0.541 |
| SNCV | -0.146 | 0.167 | -0.105 | 0.323 |

EMG, Electromyography; NRS, numeric rating scales; DML, distal motor latency; CMAP, compound muscle action potential; MNCV, motor nerve conduction velocity; DSL, distal sensory latency; SNAP, sensory nerve action potential; SNCV, sensory nerve conduction velocity.

Table 4. *Demographic data of non-PHN and PHN group.*

| | non-PHN (n = 44) | PHN (n = 47) | t/x2/Z | *P* |
|---|---|---|---|---|
| Gender | | | 1.993 | 0.158 |
| Male | 16 (36.36%) | 24 (51.06%) | | |
| Female | 28 (63.64%) | 23 (48.94%) | | |
| Age | 63.73 ± 13.63 | 64.70 ± 10.34 | 0.351 | 0.727 |
| Lesion location | | | 0.591 | 0.442 |
| Left | 18 (40.91%) | 23 (48.94%) | | |
| Right | 26 (59.09%) | 24 (51.06%) | | |
| Course of disease | 24.18 ± 18.66 | 27.66 ± 20.93 | 0.753 | 0.456 |
| Lesion area | | | 2.445 | 0.118 |
| ≤ 5% | 19 (43.18%) | 28 (59.57%) | | |
| > 5% | 25 (56.82%) | 19 (40.43%) | | |
| Immune system disease | | | 2.750 | 0.097 |
| Yes | 9 (20.45%) | 17 (36.17%) | | |
| No | 35 (79.55%) | 30 (63.83%) | | |
| The NRS score | 4.00,4.75 | 6.00,4.00 | 3.263 | 0.001 |
| Muscle strength | 5.00,0.00 | 5.00,0.00 | 0.865 | 0.397 |

Results are expressed as mean ± SD, percentages, or as medians, IQR
PHN, postherpetic neuralgia; NRS, numeric rating scales.

CI: 0.098–0.567, *P* = 0.001) and SNAP amplitude (OR = 0.268, 95% CI: 0.110–0.628, *P* = 0.002) were independent factors influencing PHN. The details are listed in Table 6.

### ROC Curve

Whether PHN occurs was used as a state variable, and the AUC for CMAP amplitude, SNAP amplitude, and their combination was calculated. The ROC curve showed that the CMAP and SNAP amplitudes of the median nerve on the affected side had high predictive values for PHN (AUC = 0.657, *P* = 0.010; AUC = 0.773, *P* < 0.001). The cutoff values were 5.45 mV and 10.80 mV, respectively. The combined predictive value of the 2 indices was the highest (AUC = 0.785, *P* < 0.001). The details are listed in Table 7, Fig. 2, and Fig. 3.

Table 5. *Comparison of EMG-related data of affected side in non-PHN and PHN group.*

| | non-PHN (n = 44) | PHN (n = 47) | t | *P* |
|---|---|---|---|---|
| DML | 7.40 ± 1.37 | 7.81 ± 2.22 | 0.799 | 0.428 |
| CMAP | 6.23 ± 1.80 | 5.01 ± 2.64 | 2.970 | 0.005 |
| MNCV | 54.13 ± 4.90 | 53.20 ± 6.97 | 0.803 | 0.426 |
| DSL | 2.23 ± 0.37 | 2.24 ± 0.69 | 0.002 | 0.999 |
| SNAP | 12.30 ± 6.67 | 6.71 ± 4.10 | 5.473 | 0.000 |
| SNCV | 54.75 ± 10.56 | 51.87 ± 15.44 | 1.176 | 0.246 |

EMG, Electromyography; PHN, postherpetic neuralgia; DML, distal motor latency; CMAP, compound muscle action potential; MNCV, motor nerve conduction velocity; DSL, distal sensory latency; SNAP, sensory nerve action potential; SNCV, sensory nerve conduction velocity.

Table 6. *Univariate and multivariate logistic regression analysis affecting the prognosis of HZ.*

| | Univariate logistic regression | | Multivariable logistic regression | |
|---|---|---|---|---|
| | Odds ratio (95% CI) | *P* | Odds ratio (95% CI) | *P* |
| DML | 0.707 (0.223-2.152) | 0.545 | | |
| CMAP | 0.304 (0.117-0.765) | 0.012 | 0.241 (0.098-0.567) | 0.001 |
| MNCV | 0.612 (0.218-1.691) | 0.343 | | |
| DSL | 0.698 (0.238-1.956) | 0.499 | | |
| SNAP | 0.296 (0.110-0.760) | 0.013 | 0.268 (0.110-0.628) | 0.002 |
| SNCV | 0.762 (0.292-1.980) | 0.575 | | |

HZ, herpes zoster; DML, distal motor latency; CMAP, compound muscle action potential; MNCV, motor nerve conduction velocity; DSL, distal sensory latency; SNAP, sensory nerve action potential; SNCV, sensory nerve conduction velocity.

## Discussion

The pathogenesis of herpes zoster is complex. Clinical studies have shown that herpes zoster is mainly caused by viral invasion of the nervous system, resulting in a series of physiological and pathological changes

Table 7. *ROC curve distribution of the CMAP, SNAP and CMAP combined SNAP amplitudes of the affected limb for PHN.*

| | AUC | 95%CI | P |
|---|---|---|---|
| CMAP | 0.657 | 0.544-0.771 | 0.010 |
| SNAP | 0.773 | 0.677-0.869 | 0.000 |
| CMAP + SNAP | 0.785 | 0.691-0.878 | 0.000 |

ROC, receiver operating characteristic; AUC, area under curve; PHN, postherpetic neuralgia; CMAP, compound muscle action potential; SNAP, sensory nerve action potential.

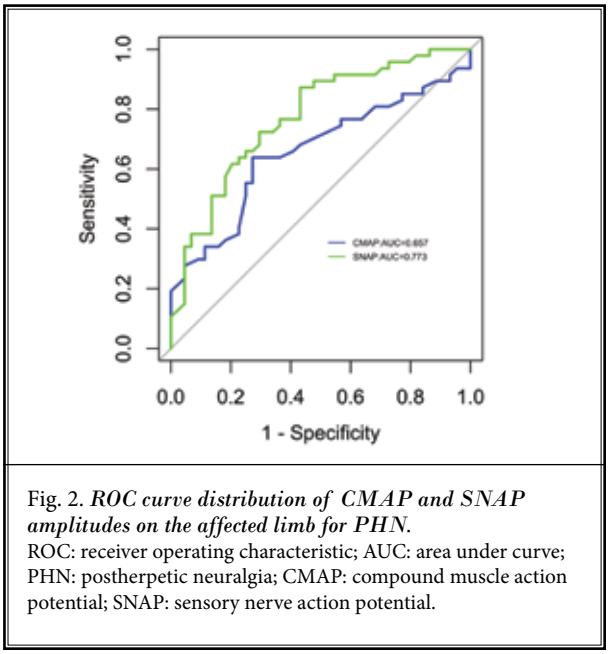


Fig. 2. *ROC curve distribution of CMAP and SNAP amplitudes on the affected limb for PHN.*
ROC: receiver operating characteristic; AUC: area under curve; PHN: postherpetic neuralgia; CMAP: compound muscle action potential; SNAP: sensory nerve action potential.

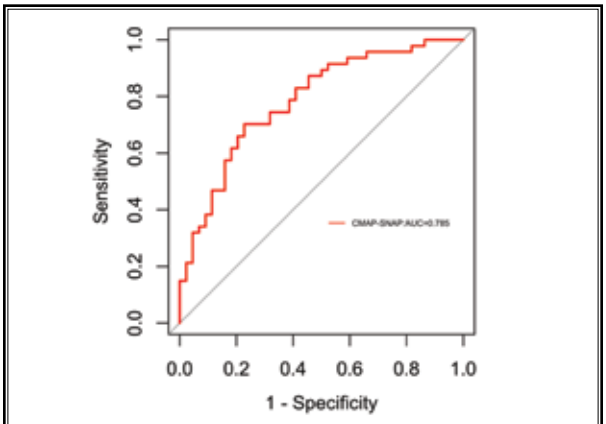


Fig. 3. *ROC curve distribution of CMAP amplitude combine SNAP amplitude on the affected limb for PHN.*
ROC: receiver operating characteristic; AUC:area under curve; PHN: postherpetic neuralgia; CMAP: compound muscle action potential; SNAP:sensory nerve action potential

in the central and peripheral nervous systems (8,12). Patients with herpes zoster often experience severe tactile pain accompanied by sleep disorders and emotional depression, resulting in a decline in their quality of life. There are also differences in the clinical treatment schemes for patients with different severities of herpes zoster (13,14). Patients with mild pain can only be treated with antiviral therapy; in more serious cases, non-steroidal anti-inflammatory drugs, antiepileptic drugs, tricyclic antidepressants, tramadol, and opioids should be administered according to the specific situation, and patients with severe pain should be treated with nerve block at the same time as oral administration of drugs. Therefore, an effective and accurate evaluation of disease severity is of great significance for the formulation of treatment plans.

At present, a common clinical index used to evaluate the disease severity is the NRS score, but it is highly subjective. In addition, recent studies have shown that the expression of T lymphocyte subsets, S100β protein, and neuron-specific enolase (NSE) in the peripheral blood are closely related to the severity of HZ (15-17). However, the results can only be obtained through complex operations, such as flow cytometry and enzyme-linked immunosorbent assay (ELISA). EMG has the advantages of being objective, accurate, and easy to perform, and it can quantify the degree of peripheral nerve injury (18). Petersen (19) proposed that severe pain with prodromal symptoms indicates that the degree of nerve injury is severe, which is consistent with the EMG results in this study. This study showed that the higher the NRS score, the lower the amplitude of the action potential on the affected limb, that is, the more serious the nerve injury. CMAP and SNAP amplitudes negatively correlated with the NRS scores. Therefore, amplitude can be used as an important index to evaluate the degree of pain. At the same time, this study also found that CMAP and SNAP amplitudes did not highly correlate with muscle strength. A possible reason for this is that the decrease in muscle strength and motor dysfunction is caused by pain or limb swelling rather than nerve fiber damage. Clinically, we cannot draw any conclusion regarding nerve fiber damage only by the decrease in muscle strength after the attack of herpes zoster.

CMAP is an evaluation of motor nerve fibers from the origin of anterior horn cells to the termination of muscle fibers, whereas SNAP provides information about sensory nerve axons and their pathways from

distal receptors in the skin to the dorsal root ganglia (20). The median nerve is a large nerve in the upper limb that occupies a large area in the central innervation area. It contains nerve root components such as C5-T1, which can better reflect upper limb function (21). Therefore, axonal damage to motor and sensory nerves can be determined according to the amplitudes of CMAP and SNAP of the median nerve, and demyelination of the nerve can be determined using NCV and DL (18). This study found that the amplitudes of CMAP and SNAP on the affected side were lower than those on the healthy side, indicating that the peripheral nerve damage of upper limb HZ involves both the sensory and motor nervous systems. Eschenfelder and Colburn (22,23) believe that the pain of patients with HZ is mainly caused by the damage of sensory nerve fibers. However, Xu and He (24-26) believed that pathological pain is caused by injury to motor fibers rather than sensory fibers. These 2 distinct conclusions were obtained from animal experiments. In this study, the EMG results showed that the pathological pain in patients with HZ was caused by damage to both the motor and sensory fibers, which was not completely consistent with these 2 views. This may be because the virus is more aggressive in humans than in laboratory animals, and the virus invades the motor and sensory nervous systems by virtue of its high degree of neuropathogenicity. In this study, it was found that the amplitudes on the affected side were significantly lower than those on the healthy side, but there was no statistical difference between the NCV and DL, indicating that the nerve injury was mainly axonal injury rather than demyelination. This is consistent with Jones and Mondelli's view (6,27).

In addition, through univariate and multivariate logistic regression analyses, it was found that the CMAP and SNAP amplitudes of the median nerve on the affected side were independent factors influencing PHN in patients with upper limb HZ. Using the ROC curve, it was found that both CMAP and SNAP amplitudes of the median nerve on the affected side had high predictive values for the occurrence of PHN, with cutoff values of 5.45 mV and 10.80 mV, respectively. It has been suggested that in the early stage of HZ, the nerves are invaded by the varicella-zoster virus, the amplitudes of CMAP and SNAP are significantly decreased, the nerves are seriously damaged, and the prognosis is poor. These cutoff values can be used as a clinical reference. The combined detection of the 2 indices has the highest predictive value for a poor prognosis. Clinically, EMG examination can be actively performed in patients with upper limb HZ, focusing on the amplitudes of CAMP and SNAP of the median nerve on the affected side. If they are at a low level, they should be alert to their serious condition and rapid progress, and timely intervention measures should be implemented to improve patient prognosis.

This study had some limitations. First, there was a lack of continuous and dynamic EMG-related data. After treatment, whether the indices of EMG in patients with HZ change with recovery of disease remains unclear, and analyzing their correlation is worthwhile. Secondly, due to the small sample size, other risk factors that may affect the prognosis of HZ could not be included in the univariate and multivariate regression analyses, such as age, gender, and course of disease. Finally, this is a retrospective study, which cannot collect all nerve conduction indicators of the upper limb except for those related to the median nerve; thus, the conclusion is not perfect.

In conclusion, the CMAP and SNAP amplitudes of the median nerve on the affected side are clinically valuable in evaluating severity and prognosis of patients with upper limb HZ. Lower CMAP and SNAP amplitudes are related to more severe pain and increased likelihood of developing PHN.

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