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The Application Effect of Electroacupuncture at Neiguan (PC6) in Patients with Consciousness Disorders

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Abstract

Objective: To investigate the efficacy of electroacupuncture at the Neiguan (PC6) acupoint in patients with disorders of consciousness. **Methods:** A total of 90 patients with post-brain injury disorders of consciousness admitted to the Department of Critical Care Rehabilitation, Neurological Rehabilitation, and Neurology at the Third Affiliated Hospital of Zhejiang Chinese Medical University from June 2024 to December 2024 were selected. These patients were randomly assigned to one of three groups: a control group, a median nerve electrical stimulation (MNES) group, and an electroacupuncture group. The control group received conventional treatment, the MNES group received conventional treatment plus MNES, and the electroacupuncture group received conventional treatment plus electroacupuncture at the Neiguan acupoint. The Glasgow Coma Scale (GCS) scores, electroencephalogram (EEG) improvement, somatosensory evoked potential (SEP) N20 latency, and brainstem auditory evoked potential (BAEP) wave I, III, and V latencies were compared among the three groups before and after treatment. **Results:** After 4 weeks of treatment, the GCS scores were as follows: (6.91 ± 1.43) for the control group, (8.15 ± 1.65) for the MNES group, and (10.04 ± 1.78) for the electroacupuncture group. The electroacupuncture group demonstrated significantly higher GCS scores compared to the control and MNES groups ($P < 0.05$). The proportion of EEG grades I and II in the electroacupuncture group (70%) was significantly higher than in the control group (33.33%) and the MNES group (50%) ($P < 0.05$). Additionally, after 4 weeks of treatment, the SEP N20 latency in the electroacupuncture group was significantly lower than that in the control and MNES groups ($P < 0.05$). Similarly, the BAEP wave I, III, and V latencies in the electroacupuncture group were significantly lower than those in the control and MNES groups ($P < 0.05$). **Conclusion:** Electroacupuncture at the Neiguan acupoint can improve GCS scores, increase the proportion of EEG grades I and II, reduce N20, wave I, III, and V latencies, and promote arousal in patients with post-brain injury disorders of consciousness.

Keywords

Electroacupuncture, Neiguan Acupoint, Median Nerve Electrical Stimulation, Disorders of Consciousness

1. Background

Disorders of Consciousness (DOC) pose a critical challenge following severe brain injury, necessitating effective treatment methods, and remain one of the most formidable issues in the field of neurorehabilitation medicine. Neuromodulation therapies, such as spinal cord stimulation, deep brain stimulation, median nerve electrical stimulation (MNES), and vagus nerve stimulation, are commonly employed to promote arousal in DOC patients [1]. MNES is a novel neuromodulation technique for arousal, with studies demonstrating its significant efficacy in improving consciousness, notably shortening the awakening process and facilitating rapid recovery [2]-[4]. The Neiguan (PC6) acupoint lies within the innervation area of the median nerve, and acupuncture at this site can directly stimulate the main trunk of the nerve. Stimulating the Neiguan acupoint activates the median nerve, the brainstem reticular formation, and the hypothalamus, thereby alleviating and reducing the excitatory state of the ascending reticular activating system caused by trauma. Building on the arousal effects of MNES, this study modified the stimulation approach by targeting the Neiguan acupoint to precisely locate the median nerve trunk, aiming to combine the benefits of electrical stimulation with traditional Chinese acupoint therapy. From June 2024 to December 2024, our research team applied electroacupuncture at the Neiguan acupoint to treat DOC patients after brain injury, achieving certain clinical outcomes. The findings are reported as follows.

2. Materials and Methods

2.1. General Information

This study selected 90 patients with disorders of consciousness after brain injury who were admitted to the Department of Critical Care Rehabilitation, Neurological Rehabilitation, and Neurology at the Third Affiliated Hospital of Zhejiang Chinese Medical University between June 2024 and December 2024. The inclusion criteria were: 1) patients in a coma with a clear history of traumatic brain injury; 2) aged between 18 and 60 years; 3) imaging examinations showing intracranial hemorrhage, subarachnoid hemorrhage, or cerebral contusion; 4) onset within 1 month and a Glasgow Coma Scale (GCS) score between 3 and 8; 5) relatively stable vital signs and no uncontrolled seizures; 6) absence of cervical spinal cord injury, right brachial plexus injury, or median nerve injury; 7) voluntary participation of family members with signed informed consent. The exclusion criteria included: 1) uncontrolled intracranial infections, hydrocephalus, hematoma, or other space-occupying lesions affecting consciousness recovery; 2) patients unable to complete treatment due to various reasons, including severe complications during treatment, transfer to other departments or hospitals, refusal or discontinuation of treatment by family members, or death. This study was approved by the Medical Ethics Committee of the Third Affiliated Hospital of Zhejiang Chinese Medical University (ZSLL-KY-2024-042-01).

Ninety patients were randomly divided into a control group, MNES group, and electroacupuncture group, with 30 patients in each group. There were no statistically significant differences in the general data among the three groups ($P > 0.05$). See Table 1.

Table 1. General information.

Groups	Example number	Gender		Age (years)	GCS Score
		Male	Female		
Control Group	30	20	10	55.13 ± 10.28	5.75 ± 1.21
MNES Group	30	18	12	51.98 ± 9.76	6.01 ± 1.52
Electroacupuncture Group	30	19	11	53.45 ± 10.43	5.98 ± 1.35
$\chi^{2/F}$		$\chi^2 = 0.675$		F = 0.153	F = 0.653
P		0.785		0.923	0.586

2.2. Treatment Methods

1) The control group received conventional treatment, including basic therapy combined with comprehensive rehabilitation. Basic therapy: surgical interventions (e.g., external ventricular drainage, decompressive craniectomy), controlled ventilation, sedation and analgesia, intracranial pressure monitoring, intracranial hypertension management, biostasis, hyperbaric oxygen therapy, treatment of traumatic cerebrovascular injury, identification and prevention of post-traumatic seizures, and secondary brain injury management. Comprehensive rehabilitation training: passive limb mobilization (upper and lower extremities), tilt table training, external diaphragm pacing, medical vibration sputum expulsion therapy, pneumatic compression therapy for lower limbs, physical factor therapy, and acupuncture.

2) The MNES group received conventional treatment plus MNES. Conventional treatment included basic therapy and comprehensive rehabilitation (same as the control group). MNES awakening therapy was performed using a median nerve electrical stimulation device (Weisheng Medical Technology Co., Ltd., Nanjing). Method: The stimulating electrode was placed 2 cm above the right wrist crease on the palmar side (median nerve point), and the reference electrode was positioned on the right thenar eminence. Stimulation parameters (based on current research literature) [5] [6]: pulse width of 300 μs, current intensity of 20 mA,

frequency of 40 Hz, on-time of 20 s, off-time of 40 s. Slight contraction of the right hand during stimulation indicated satisfactory intensity. Treatment duration: 1 hour daily, 7 days per week, for 4 weeks. All patients were followed up at 30 days via outpatient visit or telephone.

3) The electroacupuncture group received conventional treatment plus electroacupuncture at the Neiguan (PC6) point. Conventional treatment included basic therapy and comprehensive rehabilitation (same as the control group). Electroacupuncture at Neiguan was performed using a median nerve electrical stimulation device (Weisheng Medical Technology Co., Ltd., Nanjing). Method: The right Neiguan point was selected with the patient in a supine position, with the right arm naturally placed beside the body and the palm facing upward. After routine disinfection, a disposable Huatuo acupuncture needle (0.30 mm × 45 mm) was inserted perpendicularly to a depth of approximately 10 mm. The stimulating electrode was connected to the needle handle, and the reference electrode was placed on the right thenar eminence. Stimulation parameters: pulse width of 300 μs, current intensity of 1 mA - 2 mA, frequency of 40 Hz, on-time of 20 s, off-time of 40 s. Slight contraction of the right hand during stimulation indicated satisfactory intensity. Treatment duration: 1 hour daily, 7 days per week, for 4 weeks. All patients were followed up at 30 days via outpatient visit or telephone.

2.3. Observation Indicators and Evaluation Criteria

1) Glasgow Coma Scale (GCS) score [7], assessing eye-opening (max 5 points), verbal response (max 4 points), and motor response (max 6 points). Total scores range from 3 (most severe impairment) to 15 (normal). Lower scores indicate greater severity of consciousness disturbance.

2) Electroencephalogram (EEG) analysis: Common EEG patterns in prolonged coma include δ (1 - 3.5 Hz) and/or θ (4 - 7.5 Hz) waves, focal/diffuse slow waves, intermittent δ rhythms, reduced EEG amplitude, or isoelectric changes. The Young modified classification [8] was used to evaluate EEG activity based on waveform proportion, amplitude, and reactivity.

3) Somatosensory Evoked Potential (SEP): Electrical stimulation of the median nerve recorded cortical/subcortical neural activity, with N20 (short latency) as a key component. Prolonged N20 latency, reduced amplitude, or waveform disappearance correlate with impaired consciousness [9]. N20 changes were monitored to assess recovery.

4) Brainstem Auditory Evoked Potential (BAEP): Reflects functional integrity of the cochlea-brainstem pathway. BAEP alterations (e.g., latency shifts in waves I, III, and V) sensitively indicate brainstem dysfunction [10]. Wave latency changes were tracked to evaluate consciousness recovery.

2.4. Statistical Analysis

SPSS 26.0 was used for analysis. Normally distributed quantitative data were expressed as mean ± SD ($\overline{x} \pm s$). Intergroup comparisons employed one-way ANOVA (LSD Post-Hoc for homogeneous variance; Satterthwaite test for heterogeneity). Intragroup comparisons using paired t-tests. Kruskal-Wallis H test analyzed ranked data, with the Wilcoxon rank-sum test for pairwise comparisons. Significance was set at $P < 0.05$.

3. Results

3.1. Comparison of GCS Scores among the Three Groups

At admission, there was no statistically significant difference in GCS scores among the three groups ($P > 0.05$). In the control group, the GCS scores before treatment and after 4 weeks of treatment showed a statistically significant difference ($P < 0.05$). Similarly, in the MNES group, the GCS scores before treatment and after 4 weeks of treatment exhibited a statistically significant difference ($P < 0.05$). The electroacupuncture group also demonstrated a statistically significant difference in GCS scores before treatment and after 4 weeks of treatment ($P < 0.05$). After 4 weeks of treatment, the GCS scores in the electroacupuncture group were higher than those in the control group and the MNES group, with a statistically significant difference ($P < 0.05$). See Table 2.

Table 2. Comparison of GCS results among the three groups of patients.

Groups	Example number	Before treatment	After treatment
Control Group	30	5.75 ± 1.21	6.91 ± 1.43
MNES Group	30	6.01 ± 1.52	8.15 ± 1.65
Electroacupuncture Group	30	5.98 ± 1.35	10.04 ± 1.78^{abc}
F		0.538	3.923
P		4.237	0.007

Note: Compared with the same group before treatment, $^{a}P < 0.05$; compared with the control group, $^{b}P < 0.05$; compared with the MNES group, $^{c}P < 0.05$.

3.2. Comparison of Electroencephalogram (EEG) among the Three Groups

At admission, there was no statistically significant difference in EEG results among the three groups ($P > 0.05$). After 4 weeks of treatment, the proportion of EEG grades I and II in all three groups was higher than before treatment, with a statistically significant difference ($P < 0.05$). At 4 weeks post-treatment, the electroacupuncture group showed a higher proportion of EEG grades I and II (70%) compared to the control group (33.33%) and the MNES group (50%), with a statistically significant difference ($P < 0.05$). See Table 3.

3.3. Comparison of Somatosensory Evoked Potentials (SEP) among the Three Groups of Patients

At admission, there was no statistically significant difference in the N20 latency of somatosensory evoked potentials (SEP) among the three groups ($P > 0.05$). After 4 weeks of treatment, the N20 latency in all three groups was lower than before treatment, with a statistically significant difference (P < 0.05). After 4 weeks of treatment, the N20 latency in the electroacupuncture group was lower than that in the control group and the electroacupuncture group, showing a statistically significant difference (P < 0.05). See Table 4.

Table 3. Comparison of EEG results among the three groups of patients.

Groups	I level	II level	III level	IV level	V level
Control Group (n = 30)					
Before treatment	2 (6.67)	3 (10.00)	4 (13.33)	11 (36.67)	10 (33.33)
After treatment	3 (10.00)	7 (23.33)	8 (26.67)	7 (23.33)	5 (16.67)
Z			6.679		
P			<0.05		
MNES Group (n = 30)					
Before treatment	1 (3.33)	4 (13.34)	7 (23.33)	7 (23.33)	11 (36.67)
After treatment	5 (16.67)	10 (33.33)	4 (13.33)	6 (20.00)	5 (16.67)
Z			9.000		
P			<0.05		
Electroacupuncture Group (n = 30)					
Before treatment	3 (10.00)	2 (6.67)	4 (13.33)	9 (30.00)	12 (40.00)
After treatment	15 (50.00)	6 (20.00)	5 (16.66)	2 (6.67)	2 (6.67)
Z			9.535		
P			<0.05		

Table 4. Comparison of somatosensory evoked potentials (N20 latency) among the three groups of patients.

Groups	Before treatment	After treatment
Control Group	2.01 ± 0.17	1.61 ± 0.19
MNES Group	1.96 ± 0.20	1.31 ± 0.18
Electroacupuncture Group	1.93 ± 0.21	1.02 ± 0.25^{abc}
F	0.113	2.223
P	0.912	0.026

Note: Compared with the same group before treatment, ^{a}P < 0.05; compared with the control group, ^{b}P < 0.05; compared with the MNES group, ^{c}P < 0.05.

3.4. Comparison of Brainstem Auditory Evoked Potentials (BAEP) among the Three Groups

At admission, there were no statistically significant differences in the latencies of waves I, III, and V of BAEP among the three groups (P > 0.05). After 4 weeks of treatment, the latencies of waves I, III, and V in all three groups were significantly lower than before treatment (P < 0.05). Post-treatment, the electroacupuncture group showed significantly shorter latencies of bilateral N20 waves I, III, and V compared to both the control group and the electroacupuncture group ($P < 0.05$). See Table 5.

Table 5. Comparison of brainstem auditory evoked potentials (latencies of waves I, III, and V) among the three groups of patients.

Groups	Wave I		Wave III		Wave V	
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Control Group	0.19 ± 0.17	0.15 ± 0.12	0.39 ± 0.23	0.33 ± 0.16	0.44 ± 0.20	0.36 ± 0.11
MNES Group	0.18 ± 0.09	0.14 ± 0.11	0.41 ± 0.25	0.31 ± 0.11	0.38 ± 0.17	0.32 ± 0.15
Electroacupuncture Group	0.21 ± 0.12	0.10 ± 0.09^{abc}	0.40 ± 0.28	0.22 ± 0.18^{abc}	0.41 ± 0.22	0.21 ± 0.12^{abc}
F	0.120	2.184	0.253	2.354	0.358	2.583
P	0.863	0.037	0.679	0.021	0.581	0.018

Note: **Wave I** compared to the treatment group before, $^{a}P < 0.05$; compared to the control group, $^{b}P < 0.05$; compared to the MNES group, $^{c}P < 0.05$; **Wave III** compared to the treatment group before, $^{a}P < 0.05$; compared to the control group, $^{b}P < 0.05$; compared to the MNES group, $^{c}P < 0.05$; **Wave V** compared to the treatment group before, $^{a}P < 0.05$; compared to the control group, $^{b}P < 0.05$; compared to the MNES group, $^{c}P < 0.05$.

4. Discussion

Median nerve electrical stimulation (MNES) is an emerging neuromodulation technique that has garnered significant attention in both clinical and basic research in recent years. By applying electrical stimulation to the median nerve, MNES effectively promotes nerve regeneration and improves motor and sensory functions, demonstrating promising applications, particularly in the rehabilitation of nerve injuries [11]. The significance of this technology lies not only in its potential benefits for nerve injury recovery but also in its ability to open new therapeutic avenues in the field of neuromodulation. Notably, MNES has shown favorable clinical outcomes in the arousal treatment of patients with disorders of consciousness or coma [12].

MNES modulates the nervous system by stimulating the median nerve, influencing the speed and intensity of nerve conduction. Electrical stimulation enhances nerve conduction capacity and improves the efficiency of neural signal transmission. Studies indicate that electrical stimulation not only promotes nerve regeneration but also enhances the functionality of damaged nerves, particularly during post-stroke or post-traumatic rehabilitation. By regulating nerve excitability, MNES can partially restore patients' motor and sensory functions [13]. Additionally, MNES may facilitate functional reorganization of the brain by promoting neuroplasticity, aiding patients in better adapting to rehabilitation training [14].

In the treatment of comatose patients, MNES is widely used to promote consciousness recovery. Multiple studies have demonstrated that median nerve electrical stimulation significantly improves the level of consciousness and neurological function in comatose patients. Systematic electrical stimulation therapy for comatose patients has revealed that those receiving MNES exhibit superior consciousness recovery and better long-term neurological function restoration compared to conventional treatment groups [12]. These findings strongly support the application of MNES in coma treatment.

The Neiguan (PC6) acupoint, located on the medial side of the forearm between the palmaris longus and flexor carpi radialis tendons, is traditionally regarded as a key acupoint for treating cardiovascular, digestive, and emotional disorders. Anatomically, Neiguan lies in the depression between the flexor carpi ulnaris and flexor carpi radialis muscles in the mid-forearm, within the innervation area of the median nerve. Needling this acupoint can directly target the median nerve trunk. By altering the stimulation method and precisely targeting the median nerve trunk at Neiguan, the dual effects of electrical stimulation and traditional acupoint therapy can be harnessed.

Furthermore, stimulation of the Neiguan acupoint can enhance digestive tract activity and improve symptoms such as functional dyspepsia, highlighting its regulatory role in the digestive system [15]. Thus, Neiguan plays an indispensable role in modulating various physiological functions, and its anatomical location and significance in the meridian system provide a foundation for clinical applications.

Stimulation of the Neiguan acupoint significantly impacts the neurological function of comatose patients. Research indicates that electroacupuncture at Neiguan can regulate the nervous system, improve neurological function, and promote the recovery and regeneration of nerve cells in comatose patients, likely due to its modulatory effects on the central nervous system [16]. In some animal studies, electroacupuncture at Neiguan was found to reduce the expression of nerve growth inhibitory factors after ischemic brain injury, thereby promoting axonal regeneration and demonstrating its potential in nerve repair [17]. Another critical effect of Neiguan stimulation is the improvement of physiological indicators and consciousness levels in comatose patients. Studies suggest that electroacupuncture at Neiguan effectively regulates physiological parameters such as heart rate, blood pressure, and respiratory rate, thereby enhancing overall patient condition and consciousness [18] [19]. These improvements in physiological indicators, in turn, facilitate consciousness recovery, underscoring the importance of Neiguan in coma treatment.

By leveraging the dual effects of electrical stimulation and traditional acupoint therapy through Neiguan modulation, better rehabilitation opportunities are provided for comatose patients while offering a novel therapeutic approach for clinical practice. Future research should further explore the specific mechanisms of Neiguan stimulation and its efficacy in treating different types of coma, thereby providing more scientific and clinical support for the application of traditional acupuncture in coma treatment.

The results of this study show that after four weeks of treatment, the Glasgow Coma Scale (GCS) scores in the electroacupuncture group were significantly higher than those in the control and MNES groups ($P < 0.05$). The proportion of EEG grades I and II in the electroacupuncture group (70%) was also significantly greater than in the control and MNES groups ($P < 0.05$). Additionally, the N20 latency and the latencies of waves I, III, and V in the electroacupuncture group were significantly shorter than those in the control and MNES groups ($P < 0.05$). In summary, electroacupuncture at the Neiguan acupoint improves GCS scores, increases the proportion of EEG grades I and II, and reduces N20 latency, as well as the latencies of waves I, III, and V in patients with post-brain injury disorders of consciousness, demonstrating an accelerating effect on arousal.

The positive impact of electroacupuncture at Neiguan on comatose patients has increasingly gained attention. Studies suggest that electroacupuncture, by stimulating specific acupoints, effectively regulates qi and blood flow, thereby improving patients' consciousness levels. As a key acupoint, Neiguan is frequently selected in the treatment of coma due to its ability to regulate mental state and unblock meridians. Electroacupuncture not only enhances patients' arousal levels but also promotes spontaneous respiration and improves vital signs, offering an effective adjunctive therapy for the rehabilitation of comatose patients [20].

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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