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Original Article

Effects of warm acupuncture combined with stereo-dynamic interferential electrotherapy on clinical efficacy and hemodynamics of cervical spondylotic radiculopathy

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Abstract: Objective: To explore the clinical efficacy of warm acupuncture combined with stereo-dynamic interferential electrotherapy in the treatment of cervical spondylotic radiculopathy (CSR) and its effect on hemodynamics. Methods: A total of 126 patients with CSR, including 67 males and 59 females, with an average age of 49.33±8.34 years, were randomly divided into three groups, namely the warm acupuncture group, the stereo-dynamic interferential electrotherapy group and the combined treatment group, with 42 cases in each group. The combined treatment group was treated with warm acupuncture and stereo-dynamic interferential electrotherapy. The clinical efficacy, visual analogue score (VAS) and cervical dysfunction index NDI (Neck Disability Index) were compared among the three groups. The hemodynamic indexes of vertebral artery, including diameter, velocity and flow were measured by color Doppler ultrasound. The serum contents of endothelin (ET) and nitric oxide (NO) were determined by enzyme-linked immunosorbent assay (ELISA). Results: The total effective rate of the combined treatment group was higher than that of the warm acupuncture group and the stereo-dynamic interferential electrotherapy group ($P<0.05$). After treatment, the VAS and NDI scores in the combined treatment group were the lowest ($P<0.05$), while the vertebral artery diameter, blood flow velocity and blood flow were all the highest among the three groups ($P<0.05$). Compared with the warm acupuncture group and the stereo-dynamic interferential electrotherapy group, the serum ET content of the combined treatment group after treatment was decreased ($P<0.05$), and the serum NO content was increased ($P<0.05$). Conclusion: Warm acupuncture combined with stereo-dynamic interferential electrotherapy has a better therapeutic effect on CSR and can improve hemodynamics.

Keywords: Warm acupuncture, stereo-dynamic interferential electrotherapy, cervical spondylotic radiculopathy, hemodynamics, endothelin, nitric oxide

Introduction

Cervical spondylotic radiculopathy (CSR) is a kind of cervical spondylosis caused by spinal nerve root compression due to nucleus pulposus protrusion, hyperosteogeny and other reasons. It has the highest incidence in all kinds of cervical spondylosis, accounting for about 50-60% of all the cases [1, 2]. Its main clinical symptoms are neck, shoulder and upper limbs pain. Although traditional treatment methods such as head and neck traction and correction of poor posture can partially relieve symptoms, there are still problems such as limited efficacy

and easy recurrence, which seriously affect patients' lives [3, 4].

Recent years have witnessed the extensive application of traditional Chinese medicine therapy due to its remarkable effect in the treatment of various painful diseases. Acupuncture stands out as it can clear channels and activate collaterals, relieve pain and promote blood circulation. And artemisia argyi is warm and has the effect of expelling cold and relieving pain. The combination of the two is called warm acupuncture, which has been used for the treatment of periarthritis and knee osteoarthritis [5-7]. While stereo-dynamic interferential electrotherapy, a new technology developed on the traditional interference electrotherapy, can cross-input intermediate frequency current to the body, thus forming a three-dimensional stimulating effect, which has the functions of improving microcirculation, suppressing inflammation level and regulating autonomic nerves [8-10]. Shen et al. once treated patients with CSR with warm acupuncture combined with stereo-dynamic interferential electrotherapy, and found that its total therapeutic efficacy was higher than that of ordinary acupuncture [11]. However, other indicators were not systematically tested in their study, and the treatment mechanism remains unclear. Under the influence of pathological microenvironment such as inflammation, local blood vessels always found to be manifested as hemodynamic disorder, that's why this paper discusses the clinical efficacy and mechanism of combined therapy of warm acupuncture combined with stereo-dynamic interferential electrotherapy from the perspective of hemodynamics. This study is set out to explore the clinical efficacy and hemodynamics of CSR by using warm acupuncture and stereo-dynamic interference technique, so as to provide the basis for the treatment of CSR.

Materials and methods

General information

A total of 126 patients with CSR admitted to The Forth People's Hospital of Xinjiang Uygur Autonomous Region from March 2017 to March 2019 were selected as the study subjects, including 67 males and 59 females, with an average age of 49.33±8.34 years. The patients were numbered according to the order of admission, and then the random number table method was applied to randomly divide the patients into three groups: the warm acupuncture group (n=42), the stereo-dynamic interferential electrotherapy group (n=42) and the combined treatment group (n=42).

Inclusion criteria: Patients met the diagnostic criteria in the "*Expert Consensus on Standardization of Diagnosis and Treatment of Cervical Spondylotic Radiculopathy*" [12], who were informed and volunteered to participate in the study.

Exclusion criteria: Patients with upper limb numbness or pain caused by cerebrovascular diseases and other diseases; Patients with no symptoms of cervical spondylosis except imaging manifestations; Patients with tumors, fractures, mental illness or other serious diseases; Patients who could not strictly abide by the treatment regimen. The general data of patients in the three groups were collected for comparison, including gender, age, course of disease, body mass index (BMI), and height.

This study was conducted under the approval of the medical ethics committee, and written informed consent was obtained from all the subjects.

Treatment

Warm acupuncture: Warm acupuncture group: The main acupoints were neck clip ridge, Dazhui, Tianzong, Quyuan, Jianyu, Binao, Quchi and Shousanli. During the operation, the patient was placed in the prone, lateral or sitting position, and all acupuncture points were routinely disinfected. The needle tip of disposable acupuncture needle (Jiajian brand, specification: 0.30 mm × 40 mm) was directly punctured to the bone in the direction of the vertebral body, and the manipulation of mild reinforcing-attenuating was applied till acuesthesia. The needle was finally retained at Tianzong and Dazhui acupoints, and the needle handle was connected with moxibustion strips (Hanyi brand, specifications: 20 mm in diameter × 20 mm in length) for a 25 min retention, as shown in **Figure 1**. Warm acupuncture was performed once a day for 5 consecutive days as a course of treatment. With each course spaced 2 days apart, a total of 2 courses of treatment were performed.

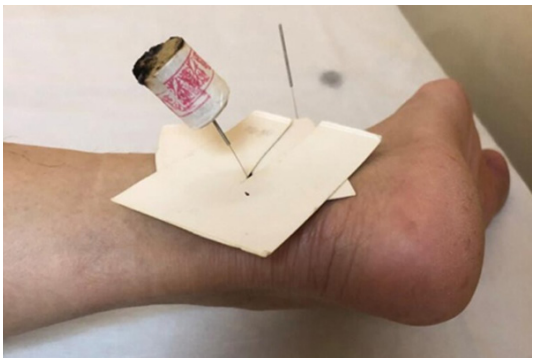

Figure 1. Warm acupuncture retention. The needle was inserted with mild reinforcing-reducing method. A 2 cm - long moxibustion strip was ignited and inserted into the needle handle and retained for 25 min. In order to prevent skin burns, 1-2 pieces of hard paper could be placed between the needle and the moxibustion strip.

Stereo-dynamic interferential electrotherapy: LDG-2-A stereo-dynamic interferential electrotherapy instrument was used for treatment. Two sets of electrodes were placed on both sides of the cervical vertebra, and the parameters were set as: basic frequency 5000 Hz, difference frequency 0-200 Hz, dynamic rhythm 10±2 s [11]. The current output intensity was determined according to the patient's tolerance degree, and it was appropriate for the patient to have a sense of comfort. The treatment lasted for 30 min, and it was performed once a day for 5 consecutive days as a treatment course. Each course was separated by 2 days, and a total of 2 courses of treatment were conducted.

Combined treatment group: Patients in the combined treatment group were treated with stereo-dynamic interference electrotherapy immediately after the warm acupuncture, and the specific methods were the same as mentioned above. The operation was performed once a day for 5 consecutive days as a course of treatment. With each course spaced 2 days apart, a total of 2 courses of treatment were carried out.

Detection indicators

Clinical efficacy: According to the Criteria of Diagnosis and Therapeutic Effect of Diseases and Syndromes of Traditional Chinese Medicine formulated by the State Administration of Traditional Chinese Medicine [13], the curative effect was divided into the following four classes: (1) Class A: clinical symptoms such as pain were improved by more than 90%; (2) Class B: clinical symptoms improved by 60-90%; (3) Class C: clinical symptoms improved by 30-60%; (4) Class D: clinical symptoms improved by less than 30%. Total effective rate = (number of cases of class A + number of cases of class B + number of cases of class C)/total number of cases × 100%.

Visual analogue scale (VAS): The VAS score ranged from 0 to 10, and the higher the score, the more intense the pain. 0 point: no pain in neck, shoulder or upper limbs; 1-3 points: mild pain that did not affect sleep; 4-6 points: severe but tolerable pain that sometimes affected sleep; 7-10 points: severe and unbearable pain that affected sleep [14].

Neck disability index (NDI): NDI scores included pain, tenderness, activity and numbness. With a total score of 25, the score was in direct proportion to the dysfunction [15].

Hemodynamic indexes of vertebral artery: The patient lay supine with the head facing left or right. The vertebral artery was detected by ACUSON S2000 color Doppler ultrasound diagnostic instrument (Siemens, Germany) with the probe frequency ranging from 5.0 to 10.0 MHz. The diameter, blood flow velocity and blood flow of the vertebral artery were measured by the spectrum analysis system.

Serum endothelin (ET) and nitric oxide (NO) contents: An amount of 2 mL venous blood of the patient was collected, left at room temperature for 30 min and then centrifuged at 6000 r/min for 20 min to retain the supernatant serum. The serum ET (Jingmei Biotechnology Co., Ltd., Jiangsu, China) and NO (Jingmei Biotechnology Co., Ltd., Jiangsu, China) contents were determined according to the instructions of enzyme-linked immunosorbent assay (ELISA) kit [16].

Statistical analysis

Statistical analysis was performed using SPSS 20.0 software. All measurement data were in accordance with the normal distribution, and expressed as mean ± standard deviation. Multi-group comparisons were performed using one-way analysis of variance, and intra-group pairwise comparisons were conducted by LSD-t test. The counting data were express-

Table 1. Comparison of general information among the three groups

Groups	Number of cases	Gender (male/female)/cases	Age/years	Course of disease/years	Body mass/kg	Height/cm
Warm acupuncture group	42	23/19	49.28±8.30	5.72±2.83	60.76±2.15	164.80±9.12
Stereo-dynamic interferential electrotherapy group	42	20/22	49.75±8.64	5.90±2.38	61.74±2.44	165.52±8.80
Combined group	42	24/18	48.96±8.07	5.36±2.95	61.39±2.03	165.74±9.33
P		0.661	0.909	0.654	0.125	0.884

Table 2. Comparison of clinical efficacy among three groups of patients

Groups	Number of cases	A class/cases	B class/cases	C class/cases	D class/cases	Total effective rate/%
Warm acupuncture group	42	3	17	14	8	80.95
Stereo-dynamic interferential electrotherapy group	42	2	18	12	10	76.19
Combined group	42	8	21	11	2	95.24*,#
χ^2						6.181
P						0.045

Note: *P<0.05, compared with the warm acupuncture group; #P<0.05, compared with the stereo-dynamic interferential electrotherapy group.

ed as the number of cases/percentage and compared using the χ^2 test. A statistically significant difference was assumed at P<0.05.

Results

Comparison of general information among the three groups

No statistical differences were observed in gender, age, course of disease, body mass, or height among the three groups of patients (P>0.05), and their general information was comparable (**Table 1**).

Combination therapy can improve clinical efficacy

The total effective rate of the combined treatment group was higher than that of the warm acupuncture group and the stereo-dynamic interferential electrotherapy group, and the difference was statistically significant (P<0.05, **Table 2**).

Combination therapy can reduce VAS and NDI scores

There were no significant differences in VAS and NDI scores among the three groups before treatment, while after treatment (P>0.05), the VAS and NDI scores dropped markedly in all the three groups, with statistically significant difference (P<0.05). After treatment, the scores of VAS and NDI in the combined treatment group were lower than those in the warm acupuncture group and the stereo-dynamic interferential electrotherapy group, and the difference was statistically significant (P<0.05, **Table 3**).

Combination therapy can improve the hemodynamic indexes of vertebral artery

The hemodynamic indexes represented by vertebral artery diameter, blood flow velocity and blood flow did not differ significantly among the three groups before treatment (P>0.05). While after treatment, the above three indicators raised notably, with statistically significant difference (P<0.05). The post-treatment vertebral artery diameter, blood flow velocity and blood flow in the combined treatment group were remarkably higher than those in the rest two groups, and the differences were statistically significant (P<0.05, **Table 4**).

Combination therapy can reduce serum ET content and increase serum NO content

The serum ET content of the three groups reduced markedly, while the serum NO content elevated greatly after treatment, with statistically significant differences (P<0.05). Before treatment, there was no significant difference in serum ET or NO content among the three groups (P>0.05). While after treatment, the ET content was the lowest and the NO content was the highest in the combined treatment group among the three groups, and the differ-

Table 3. VAS and NDI scores before and after treatment in three groups

Groups	Warm acupuncture group	Stereo-dynamic interferential electrotherapy group	Combined group	F	P
Number of cases	42	42	42		
VAS/score					
Before the treatment	5.46±0.77	5.50±0.68	5.69±0.85	1.070	0.346
After the treatment	2.24±0.39*	2.16±0.41*	1.52±0.30a,b,*	47.840	<0.001
NDI/score					
Before the treatment	38.50±4.66	38.95±4.82	38.11±4.63	0.335	0.716
After the treatment	24.77±3.91*	25.50±4.04*	17.87±3.36a,b,*	52.070	<0.001

Note: aP<0.05, compared with the warm acupuncture group after the treatment; bP<0.05, compared with the stereo-dynamic interferential electrotherapy group after the treatment; *P<0.05, compared with before the treatment. VAS: visual analogue scale; NDI: neck disability index.

Table 4. Comparison of vertebral artery blood flow dynamics in three groups of patients

Group	Pipe diameter/mm	Blood flow velocity/(cm/s)	Blood flow/(ml/min)
Number of cases	42	42	42
Warm acupuncture group			
Before the treatment	3.03±0.25	13.92±2.04	62.04±8.55
After the treatment	3.30±0.31*	16.26±3.14*	90.67±11.37*
Stereo-dynamic interferential electrotherapy group			
Before the treatment	3.05±0.24	13.83±1.95	61.89±8.61
After the treatment	3.28±0.29*	16.05±2.77*	88.93±12.66*
Combined group			
Before the treatment	3.03±0.22	13.90±2.01	61.77±8.29
After the treatment	3.45±0.32a,b,*	18.61±2.98a,b,*	105.22±14.58a,b,*

Note: aP<0.05, compared with the warm acupuncture group after the treatment; bP<0.05, compared with the stereo-dynamic interferential electrotherapy group after the treatment; *P<0.05, compared with before the treatment.

ences were statistically significant (P<0.05, **Tables 5**, **6**).

Discussion

Through the stimulation of local receptors, acupuncture can not only reflexively inhibit sympathetic activity, alleviate muscle spasms in the neck, promote vasodilation and microcirculation, but also reduce inflammation levels, correct the disorders of cervical anatomical and biomechanical relations of the cervical vertebrae, and inhibit nerve root stimulation or compression caused by various factors [17, 18]. In addition, through the heat of moxibustion fire and the temperature-warming and medicinal properties of artemisia argyi, moxibustion can exert the effect of removing dampness and cold, regulating body temperature and osmotic pressure balance [19, 20]. Warm acupuncture is the synergistic combination of acupuncture and moxibustion, which can significantly enhance the above physiological functions and improve the treatment efficacy.

Stereo-dynamic interferential electrotherapy is a safe, effective and non-invasive physical therapy, and the dynamic current input to the body has a variety of stimulation sites and intensity. It has a variety of physiological effects: (1) The current conducted in different directions can stimulate tissue structures such as nerve cells and muscle fibers from all directions; (2) Dynamic alternating intensity stimulation helps to avoid adaptive or fatigue effects caused by a single high-intensity stimulation; (3) The pain threshold of tissues is increased to promote the generation and release of enkephalin and inhibit the release of various pain factors [8-10].

In this study, warm acupuncture and stereo-dynamic interferential electrotherapy were ap-

Table 5. Comparison of serum ET content in three groups of patients

Groups	Warm acupuncture group	Stereo-dynamic interferential electrotherapy group	Combined group	F	P
Number of cases	42	42	42		
ET (ng/L)					
Before the treatment	97.59±8.45	96.98±8.54	97.64±9.37	0.073	0.929
After the treatment	69.53±6.60*	67.53±6.17*	55.88±5.33a,b,*	62.220	<0.001

Note: aP<0.05, compared with the warm acupuncture group after the treatment; bP<0.05, compared with the stereo-dynamic interferential electrotherapy group after the treatment; *P<0.05, compared with before the treatment. ET: endothelin.

Table 6. Comparison of serum NO content in three groups of patients

Groups	Warm acupuncture group	Stereo-dynamic interferential electrotherapy group	Combined group	F	P
Number of cases	42	42	42		
NO (ng/L)					
Before the treatment	17.39±3.70	16.99±3.74	17.78±3.25	0.514	0.599
After the treatment	54.45±10.80*	54.13±9.98*	63.30±11.12a,b,*	10.040	<0.001

Note: aP<0.05, compared with the warm acupuncture group after the treatment; bP<0.05, compared with the stereo-dynamic interferential electrotherapy group after the treatment; *P<0.05, compared with before the treatment. NO: nitric oxide.

plied to treat patients with CSR in the hope that the synergistic effect of the two can enhance the therapeutic effect and improve the hemodynamic indexes. The clinical efficacy evaluation of the patients after treatment revealed that the total effective rate of the combined treatment group was higher than that of the warm acupuncture group and the stereo-dynamic interferential electrotherapy group, confirming the effectiveness of the combined treatment of the two, which was consistent with the results of the study by Shen et al. [11]. What's more, VAS and NDI evaluated the treatment efficacy of patients from the aspects of pain degree and dysfunction, and the results demonstrated that both warm acupuncture and stereo-dynamic interferential electrotherapy could reduce VAS and NDI, but the effect of combined treatment was most significant.

The dislocation of the biomechanical relationship at the cervical spine and the imbalance of the microenvironment such as inflammation can affect local blood vessels, leading to hemodynamic disorders, which are manifested in reduced blood flow velocity and blood flow. In the present study, color Doppler ultrasound examination of the vertebral artery found that the combination of warm acupuncture and stereo-dynamic interferential electrotherapy could improve the diameter, blood flow velocity and blood flow of the vertebral artery, which may be related to the enhanced vasodilation caused by the synergistic effect of the two. ET is a potent vasoconstrictor synthesized and secreted by vascular endothelial cells, and its increased content may aggravate the insufficient blood supply of the neck and neck [21, 22]. While NO is a fat-soluble bioactive substance that exerts vasomotor effect by acting on vascular smooth muscle cells [23, 24]. The results of this study exhibited that both warm acupuncture and stereo-dynamic interferential electrotherapy could reduce serum ET content and up-regulate the NO content, indicating that warm acupuncture and stereo-dynamic interferential electrotherapy were involved in the mechanism of promoting vasodilation, which played a role by regulating the content of vasoactive substances in serum. The improvement of the above hemodynamic indexes by combination therapy may be related to multiple mechanisms: (1) The direct stimulation effect of acupuncture and diversified electric currents on vascular smooth muscle and vascular endothelial cells; (2) Local heating effect of moxibustion fire and artemisia argyi; (3) Inhibition of the release of inflammatory and pain causing factors and improvement of local microenvironment.

The shortcomings and prospects of this paper are as follows: (1) This study only includes pa-

tients with CSR. Whether the combined treatment has a therapeutic effect on other types of cervical spondylosis, such as vertebral artery type, remains unclear, which needs further exploring; (2) The acupoint and time of warm acupuncture retention, and the frequency and rhythm of stereo-dynamic interferential electrotherapy still need to be optimized in order to improve the therapeutic effect; (3) The mechanism of combination therapy in improving hemodynamics has not been deeply discussed in this paper. In the future, studies will be conducted from multiple perspectives such as calcium pump activity of vascular smooth muscle and endothelial progenitor cells.

To sum up, warm acupuncture combined with stereo-dynamic interferential electrotherapy enjoys a better therapeutic effect on CSR and can improve the state of hemodynamics.

Disclosure of conflict of interest

None.

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