**Motor entry point acupuncture for shoulder abduction dysfunction after stroke: a randomized controlled feasibility trial**

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**Abstract**

**Introduction:** Evidence has suggested that shoulder abduction dysfunction after stroke can be treated with acupuncture, but it remains unclear which acupuncture approach may be more effective. This trial compared two different acupuncture interventions (Motor Entry Point acupuncture (MEPA) and Standard acupuncture (SA) for patients experiencing post-stroke shoulder abduction dysfunction.

**Methods:** Hospital in-patients with post-stroke shoulder abduction dysfunction of two weeks duration and who agreed to participate in the trial were randomized into two groups. The SA group received acupuncture treatment at LI15, LI14, LI11, LI10 and LI4 (n=20); the MEPA group received acupuncture at the mid-third of deltoid (n=20). Each group received acupuncture for 40 minutes, 6 times a week for 4 weeks. Outcomes were the range of motion (ROM) and the manual muscle test (MMT).

**Results:** Forty in-patients (19 women, 21 men; age range: 35-75 years) were enrolled in this trial. There was significant improvement in shoulder abduction dysfunction in both groups after 4 weeks of treatment (P＜0.05). The MEPA group reported larger ROM and improved MMT compared to the SA group (P＜0.05) and the recovery of muscle strength in MEPA group was superior to the SA group (P＜0.05).

**Conclusion:** Compared to SA therapy, MEPA therapy may be more effective for treating physical functional disability in post-stroke patients.

**Keywords:** Motor Entry Point; Acupuncture; Shoulder abduction dysfunction; Stroke; Deltoid; randomized controlled trial

**Introduction**

Stroke is a global medical problem because of its high incidence, morbidity, mortality, and rate of relapse [1]. A majority of individuals who have experience a stroke report impaired upper extremity function as a major and unsolvable problem, and this can seriously affect survival and quality of life [2]. Between 22％ to 90％ of stroke survivors may have upper limb dysfunction, which severely limits an individual’s autonomy to successfully reintegrate into family, work and social life [2]. Some studies have assessed the effect various interventions on shoulder dysfunction of post-stroke such as using an arm sling [3], upper limb taping [4], or robot-assisted upper limb rehabilitation [5]. However, the use of an arm sling may lead to difficulty in walking because the patient is unable to symmetrically move both arms while walking [6]; taping may be related to trauma to the skin at the attached area [7]; and robot-assisted therapy is not universally used due to its high cost [8].

As early as 1997, the National Institutes of Health consensus statement suggested that acupuncture may be useful for post-stroke patients’ rehabilitation [9]. Recent systematic reviews on post stroke shoulder pain have suggested that acupuncture may be beneficial for stroke rehabilitation [10-11]. The *Huangdi’s Internal Classic* [黄帝内经] suggested a theory (“Treatment for Flaccidity aims at *Yangming* Meridian”) which has been widely used as a clinical guideline for acupuncture for *Weizheng* [痿症] (paralysis). Shoulder dysfunction after stroke belongs to *Weizheng* in Traditional Chinese Medicine (TCM) theory [12]. Both clinical and animal studies have previously demonstrated the efficacy of acupuncture using points on the *Yangming* meridian for stroke and post-stroke shoulder dysfunction [13-16]. LI15 (Jianyu), LI14 (Binao) and LI11 (Quchi) are commonly used even internationally as clinical treatments for shoulder dysfunction [17-19].

Though some evidence has shown that traditional acupuncture treatments have an effect on post-stroke shoulder abduction dysfunction [20-21], clinical efficacy may not be satisfactory and some reviews reported traditional acupuncture may not improve motor function or other outcomes [22-24]. In clinical practice, we observed that to improve the motor function of stroke patients acupuncture stimulation of nerves appeared to have a better effect compared with treating traditional acu-points, so locating acupuncture needling at the place where nerves collect may be efficacious as a therapy [25-27].

The motor entry point (MEP) is the place where the nerve ends collect. As a result it is easy to activate the muscle when the points are stimulated [28]. Evidence showed that the function of muscles of patients after stroke was considered as an important focus of assessment and intervention, and also as a potential biomarker during the stroke disease course [29].The available information [30] suggests that muscle spindles are unevenly distributed in the same muscle and they are mostly located at the motor entry point. The MEP of some muscles has been located accurately [31-33] which has helped in muscle transplantation and ensures an effective zone for injections into the muscle [34-36]. The distributions of muscle spindles are associated with the function of muscle and the distribution of nerve branches [30, 37]. There is evidence that there are more motor end-plates and muscle spindles at motor entry points [38-39].

Preliminary findings were presented in our previous research [40], but there is still limited evidence on the MEPA for shoulder abduction dysfunction of post-stroke patients, and insufficient evidence comparing MEPA and SA. The aim of this comparative effectiveness trial was to evaluate if acupuncture at motor entry point was more effective than acupuncture at the existing acu-points which are commonly used in clinical practice for managing shoulder abduction dysfunction after stroke.

**Methods**

**Ethics approval**

Ethical approval for this trial was given by the medical ethics committee of the second affiliated hospital of Heilongjiang University of Chinese Medicine (HZYLLKY201301201).

**Design**

This was a randomized controlled trial with blinded to the doctor who assessed the patients and outcomes. This trial was reported according to the CONSORT guidelines.

**Clinic Setting**

This trial was conducted in the first rehabilitation stroke unit of the second affiliated hospital of Heilongjiang University of Chinese Medicine.

**Patients**

During March 2014 to August 2014 all in-patients who exhibited shoulder abduction dysfunction following a stroke and who met the inclusion criteria were asked to participate in the trial.

The inclusion criteria were: (1) Aged between 18 and 80 years; (2) Cerebral hemorrhage or infarction diagnosed by craniocerebral CT scan and/or MRI examination; (3) Two weeks within the onset of a stroke with shoulder abduction dysfunction (abduction angle＜30°), and no dysfunction before stroke; (4) No serious cognitive impairment, no sensory aphasia, able to understand basic instructions (score of mini-mental state examination(MMSE)＞24); (5) Manual muscle test (MMT) on the deltoid of the side of the hemiplegia was below level 3; (6) No acupuncture treatment in the past two weeks. Exclusion criteria were: (1) Subarachnoid hemorrhage, secondary cerebral infarction or with severe neck lumbar lesions or upper limb joint disease, other diseases of the nervous system and vestibular or cerebellar dysfunction; (2) During the treatment occurrence of a new cerebral infarction or cerebral hemorrhage; (3) Upper limb spasm or severe pain; (4) Using other treatment options during the process of this study.

**Sample size**

Sample size was calculated based on a ratio of 1:1 between the both groups. This sample size was based on a study [41] in which ROM activity before and after treatment was equal to 112.15 (25.89) and 115.46 (26.18) in the control group and 113.89 (30.20) and 129.69 (26.96) in the treatment group, and considering 70% of power and alpha of 0.05, as well as two-tailed difference in ROM activity before and after treatment in each group.

**Randomization**

After providing signed informed consent, patients meeting the inclusion criteria were randomly allocated at a ratio of 1:1 to standard acupuncture (SA) group or motor entry point acupuncture (MEPA) group with an equal probability by using block randomization with a table of randomization, which included all possible combinations of a small series of figures. The order of different interventions assigned to each block was also randomized. This process was repeated for consecutive blocks until all the included participants were randomized. Participants would be given sequential treatment cards from an independent clinical research coordinator (XYL) at the first treatment to ensure adequate concealment. Of sixty-one patients assessed, forty were eligible and were allocated to one of the two groups.

**Interventions**

**Standard acupuncture (SA) group**

Patients in SA group received manual acupuncture at traditional acu-points on the upper extremity. The literature suggested standard points and these were chosen for this study on the side of the paralysis: LI15 (Jianyu), LI14 (Binao), LI11 (Quchi), LI10 (Shousanli), LI4 (Hegu) [13-16].

**Motor entry point acupuncture (MEPA) group**

Patients in MEPA group received manual acupuncture at the motor entry point of the deltoid muscle. According to a previous study [42], we chose the mid-third part of deltoid muscle and acupuncture was applied using two needles at either side of the muscle fiber on the side of the paralysis.

The location of motor entry points on the deltoid has been demonstrated anatomically, and is determined by the form of the muscle [28]. The deltoid is the most important muscle of the shoulder for abduction as it consists of three muscle fibers which govern the movement of arms in the shoulders, especially when the shoulder abduction angle is between 15° to 90° [43]. One study [31] has reported that there are three muscle fibers in the deltoid suggesting that there are three motor entry points: The anterior one locates below (5.7±0.7) cm from the shoulder peak and (3.6±0.4) cm on the back from the anterior edge of the deltoid; the lateral one locates below (5.9±0.8) cm from the shoulder peak and (3.5±0.6) cm anterior to the post-lateral edge of the deltoid, and the posterior one locates below (4.8±0.5) cm from shoulder peak and (2.3±0.3) cm anterior to the post-lateral edge of the deltoid. All the three points are located in the mid-third of the deltoid irrespective of gender. (Figure 1)

Figure 1 The location of motor entry point for shoulder dysfunction

Participants in the both groups were received rehabilitation treatments including therapeutic exercises for muscles around shoulder joint for 30min every treatment day, and oral western medicine such as antihypertensive drugs, hypoglycemic and antiplatelet aggregation drugs.

Disposable stainless steel needles (0.3mm×50mm, *Huatuo*) were inserted into the muscle using a twisting technique which was applied until participants felt a *de qi* sensation with a depth of 0.8 cun, and oblique to form on angle approximately 45 degree with the skin. Each treatment lasted 40 minutes. The two groups received one session of acupuncture treatment six times a week (except Sundays) for four weeks, and each patient received a total of 24 treatments.

**Outcome measures**

The primary outcome was participants’ physical functional ability as measured by the range of motion (ROM), and the secondary outcome was the manual muscle test (MMT). The assessments were carried out twice: one was 30min before the first needling and one was 30min after the last needling.

Active Range of Motion (AROM) assessed ROM and standardized the measurements by using the method of Norkin and White [44]. The 0-180° measurement system was utilized by Silver [45]. Measurements were standardized according to the American Academy of Orthopedic Surgeons and American Medical Association [46-47]. In this study, the changes in ROM were categorized as follows: Invalid--had no change (shoulder abduction angle was＜30°); Effective-- shoulder abduction angle was between 30°-90°; Excellent-- shoulder abduction angle was between 90°-150°; Cure-- shoulder abduction angle was normal (＞150°). Manual muscle test (MMT) [48] in shoulders of stroke patients was conducted by neurologists experienced in paralysis.

Both outcomes were assessed prior and post treatment. An independent doctor (GX) with over two years’ of rehabilitation training assessed all patients by medical and physical examinations. The doctor was not involved in any part of the clinical trial and did not know the group allocation. A clinical research coordinator (XYL) who also did not know the group situation administered all questionnaires. The aim of using the same doctor (GX) was to reduce testing variation and maximize the consistency of the measuring the outcomes [49-50].

**Quality control**

The reasons for any dropouts or withdrawals during the treatment period were fully recorded in this study. To ensure quality of this trial, the quality monitors based in the university investigated all the process details regularly and checked the authenticity of the data. All the acupuncturists (n=4) were involved in training for the trial and knew the location of the points, depth and direction of needling before recruitment.

**Statistical analysis**

In order to evaluate any potential differences between two treatment groups, demographic characteristics were compared between both groups using the independent t-test and chi-square test. Demographic data for the patients, including gender, age, types of stroke, the side of the hemiplegia, and course of stroke, in both groups were compared using t-test and chi-square test. Frequencies were calculated for categorical variables. For continuous variables, means ± standard deviations (SD) were obtained. To verify the trial hypothesis, ROM and MMT of pre- and post-treatments were computed and analyzed by nonparametric rank sum test. Statistical Package for Social Science (SPSS, ver.17.0, IBMInc., IL, USA) was used for the statistical analysis. A p value﹤0.05 was defined as being a significant statistical difference.

**Results**

**Patient Characteristics**

Forty patients (19 women, 21 men; age range: 35-75 years) were randomized and started treatment. No patient dropped out during the four-week interventions and there were no serious adverse events, all the forty patients were included in data analysis (Figure 2). No significant differences were observed between the two groups in the variables measured at baseline including age, types of stroke, the side of the hemiplegia and course of disease (Table 1).

Table 1 Baseline patient characteristics

Figure 2 CONSORT flow diagram

**Results of range of motion (ROM)**

For both pre and post treatment outcomes, the same physical therapist performed all the ROM measurements (Table 2). Results from rank sum test showed that before the treatment, there was no significant difference between the two groups (*Z*=-0.754, *P*=0.451); before and after treatment comparisons, demonstrated a significant difference in the SA group (*Z*=-2.029, *P*=0.043) and also for the MEPA group (*Z*=-2.006, *P*=0.012). For the results of total clinical effective of ROM, there was a significant difference between the two groups (*Z*=-2.119*, P*=0.024). The results demonstrated that both types of acupuncture were effective in improving ROM of stroke patients, but MEPA was more effective than SA.

Table 2 Comparison of ROM pre- and post- treatment

**Results of manual muscle test (MMT)**

The same physical therapist performed all the MMT measurements pre and post treatment (Table 3). Results from rank sum test showed that before the treatment, there was no significant difference between the two groups (*Z*=-1.206, *P*=0.624); the before and after treatment comparison demonstrated that there was a significant difference in the SA group (*Z*=-2.306, *P*=0.024) and in the MEPA group (*Z*=-3.771, *P*=0.011). After the treatments, there was a significant difference between the two groups (*Z*=-3.382, *P*=0.031). The results demonstrated that both types of acupuncture were effective in improving MMT of stroke patients, but MEPA was more effective than SA.

Table 3 Comparison of MMT pre- and post- treatment

**Discussion**

**Summary of the main findings**

In most cases, upper limbs recovery after stroke needs specific and precise training tasks [51-52], and our research indicated a better tendency for shoulder function improvement by MEPA intervention. In this trial, 40 post-stroke patients with shoulder abduction dysfunction all completed the four-week interventions. No adverse events were reported during the trial. There were no significant differences at baseline between the two groups. After interventions, the results showed that both standard acupuncture and motor entry point acupuncture therapy could improve ROM and MMT for shoulder abduction dysfunction after stroke, but the latter appeared to be more efficacious.

**Findings from other previous studies**

The Chinese medicine literature has reported that acupuncture has been used for shoulder dysfunction after stroke in almost all Chinese hospitals in China [53], and the motor entry point acupuncture is a new therapy which combines traditional acupuncture treatment with anatomical theory. More and more studies have been focused on locating the MEP of different muscles, and realized the function of MEP stimulating for some diseases caused by nerve damage [26, 54-57]. Some other clinical trials were conducted to assess MEPA in post-stroke patients. One study showed that compared to SA, MEPA on the deltoid muscle had a better effect on improving motor functions of upper limbs as evaluated by the Fugl-Meyer Assessment, Modified Barthel Index and the Modified Ashworth Scale [27], and two studies showed that[25, 58] compared to SA, MEPA on quadriceps femoris muscle had a better effect on knee control as evaluated by Fugl-Meyer Assessment, Modified Barthel Index and in terms of functional ambulation.

The findings from other clinical studies have shown similar results to this trial that MEPA was efficacious for post-stroke patients in improving the functions of upper and lower limbs [25-27, 57].

**Acupuncture for shoulder function after stroke**

One study has shown that by stimulating LI11, muscle strength can be improved, while the tension can be reduced in the same muscle [58]. Xue et al reported that electro-acupuncture at LI11 could exert anti-apoptotic effect through the modulation of TLR4/NF-KB signaling pathway on cerebral ischemia-reperfusion injury [59]. Other studies have suggested that LI14 can be used to treat upper limb dysfunction [13] and LI15 is useful for paralysis of the arm [60]. Another study [61] demonstrated that electrical stimulation at LI14 and LI15 during acute stroke could improve the strength of upper limb. In addition to the above, clinical research has reported that *Jingjin* [筋经] (sinews affiliated to twelve main meridians) acupuncture could be a way to treat shoulder dysfunction [62]. Xu et al [63] demonstrated that *JIN’S* three needling technique on the shoulder was effective for shoulder dysfunction after stroke, and warm acupuncture therapy was used for treating shoulder dysfunction in another report showed a similar clinical effectiveness [64].

**The reasons for choosing motor entry point acupuncture and the possible mechanism**

It is generally believed that acupuncture can adjust neuron activities by stimulating the acu-points [65]. Acupuncture is relaying the information of sense and movement to the brain and the central nervous system and giving feedback to peripheral nerves [66] so that the muscle of dysfunction can be restored. Because of more motor end-plates which are the essential for muscle movement [38, 67] at the motor entry points, motor entry points were selected for acupuncture in this study. Evidence pointed out that the thickness of the muscles and morphology changes could be found on the paralysis side with the post-stroke survivors [68]. From the evidence, the authors in this study speculated that the motor entry point acupuncture treatment might directly stimulate the nerve in deltoid muscle which could provide nutrition to the muscle, therefore the function of shoulder of post-stroke patients could recover.

The possible mechanism of motor entry point acupuncture treatment may be because puncturing MEP could restore the damaged motor-end-plate. Little data are available concerning the change of quantity and form of muscle spindles in post-stroke patients. Nevertheless the related studies reported that muscle spindles would reduce or even disappeared without nutrition providing to the nerves [69-70]. Some studies have demonstrated that adult neural stem cells in the nervous system still exist and that they could develop into mature and normal function of neurons under the appropriate conditions. The results of this study reported the MEP acupuncture was effective and it was better than the standard acupuncture.

**Hints for future studies**

In order to investigate the exact mechanism, an on-going project by the same team has selected electromyography (EMG) measurement [71] which could record the changes about biological electrical signals when the muscle moves as the test for clarifying the mechanism of motor entry point acupuncture treatment. One study has shown that between 9％ to 40％ post-stroke patients have shoulder pain [72]. Also in this study, fewer participants (seven in SA group and five in MEPA group) were in pain after treatment while thirty-one (seventeen in SA group and fourteen in MEPA group) were in pain before treatment. From the amount of reduction in shoulder pain reported we anticipate that motor entry point acupuncture might be helpful for reducing pain but we did not measure shoulder pain in this trial. A Visual Analogue Pain Scale (VAS) assessment will be added as an outcome in a future study.

**Limitations**

This trial compared two different acupuncture approaches both of which are used in routine clinical care at the hospital and therefore no placebo/sham control was used.. As suggested in the literature [73-76], a pragmatic approach without sham control in evaluating using a holistic approach is more acceptable to this population. The different numbers of acu-points used in the two groups may cause heterogeneity. A sham-placebo controlled group can be misleading and unacceptable because procedures including placebo acupuncture, sham acupuncture and minimal acupuncture have not been standardized [77-78]. As mentioned above, there was no pain scale assessment in this paper, but pain was a main complaint of the post-stroke patients. Further trials in large populations with more rigorous design are warranted to ensure external validity because only Chinese patients in a single-center were assessed in this trial.

**Conclusion**

Compared to SA therapy, MEPA therapy may be more effective for shoulder abduction dysfunction in post-stroke patients as assessed by functional ability.

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**Author Contributions**

Conceived and designed the study: GX, XYL; Performed the study: WZJ, LZS, ZY, GX, XYL; Performed the measurements: WZJ; Analyzed the data: LZS; Wrote the paper: WZJ, LZS; Revise the paper: HXY, RN. Advised on the initial study protocol, helped draft and edited the paper NR.All the authors read and approved the final manuscript.

**Declaration of Competing interests**

All authors declare that they have no conflict of interest. NR is editor in Chief of the European Journal of Integrative Medicine and has been involved since the inception of this research.

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Figure 1 The location of motor entry point for shoulder dysfunction

Figure 2 CONSORT flow diagram

Table 1 Baseline patient characteristics

Table 2 Comparison of ROM pre- and post- treatment

Table 3 Comparison of MMT pre- and post- treatment