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Disclosures:

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0894-9115/03/8201-0021/0
American Journal of Physical Medicine & Rehabilitation

DOI: 10.1097/01.PHM.0000043517.06642.D0

Research Article

Clinical Trial of Acupuncture for Patients with Spinal Cord Injuries

ABSTRACT

Wong AMK, Leong CP, Su TY, Yu SW, Tsai WC, Chen CPC: Clinical trial of acupuncture for patients with spinal cord injuries. *Am J Phys Med Rehabil* 2003;82:21–27.

Objective: To examine whether electrical acupuncture therapy through adhesive surface electrodes and concomitant auricular acupuncture therapy could improve the neurologic or functional recovery in acute traumatic spinal cord injury patients.

Design: A total of 100 acute traumatic spinal cord injury patients with American Spinal Injury Association (ASIA) impairment grading of A and B were recruited into this study. They were randomly divided into the acupuncture and control groups. In the acupuncture group, electrical acupuncture therapy via the adhesive surface electrodes were applied to the bilateral Hou Hsi (SI3) and Shen Mo (B62) acupoints. In auricular acupuncture, four acupoints related to the spinal cord were selected for stimulation at the antihelix, helix, and lower portion of the ear-back areas. Acupuncture therapy was initiated early in the emergency room setting or soon after spinal surgical intervention. Rehabilitation therapy was also provided to the patients during acupuncture therapy. In the control group, only rehabilitation therapy was provided to the patients. Neurologic and functional scores were assessed during the time of admission, hospital discharge, and 1-yr postinjury follow-up.

Results: There were significant improvements in neurologic (sensory and motor), functional, and FIM™ scores in the acupuncture group compared with the initial admission period when assessed during the time of hospital discharge and the 1-yr postinjury follow-up. A greater percentage of patients in the acupuncture group recovered to a higher ASIA impairment grading.

Conclusion: The use of concomitant auricular and electrical acupuncture therapies, when implemented early in acute spinal cord injury, can contribute to significant neurologic and functional recoveries.

Key Words: Spinal Cord Injury, American Spinal Injury Association, Rehabilitation, Electrical Acupuncture, Auricular Acupuncture

Spinal cord injury (SCI), a traumatic insult to the spinal cord, can result in alternations of normal motor, sensory, and autonomic function.[1] When the traumatic episode is severe enough, many SCI patients do not recover from the lost neurologic functions.[2] As a result, some of them will pursue alternative treatments, such as acupuncture, in hoping for possible improvement in neurologic recovery.

Acupuncture is an ancient Chinese therapy practiced for more than 2500 yr to cure disease and relieve pain.[3] In 1979, the World Health Organization drew up a provisional list of 47 diseases that could be treated with acupuncture. Neurogenic bladder, which can be an impairment encountered in SCI patients, was referenced as potentially treatable with acupuncture.[4]

Politis and Korchinski[5] reported the use of "first-aid" acupuncture treatment in rats with experimental standardized spinal cord contusion at the eighth thoracic spinal level (T8 level). Results showed that when acupuncture therapy was initiated within 15 min after surgery, minimization of posttraumatic cord shrinkage and remarkable sparing of ventral horn neurons became evident. A clinical study on humans also reported improvement in 120 paraplegic patients after acupuncture therapy.[6]

Acupuncture is an invasive procedure in which thin metal needles are inserted into specific body sites and slowly twisted manually or stimulated electrically. As a result, it carries the risks of local pain, hematoma formation, infection, and even syncope. Therefore, acupuncture should only be performed by certified acupuncturists. The uncomfortable pain sensation induced by needle manipulation could be replaced by the application of electrical acupuncture in which adhesive surface electrodes are used. It was postulated to be an effective treatment method in terms of functional recovery in hemiplegic stroke patients.[7]

The purpose of this study was to examine whether concomitant treatment of electrical acupuncture through adhesive surface electrodes and auricular acupuncture therapies could improve the neurologic or functional recoveries in acute traumatic SCI patients. The effectiveness of therapy was assessed based on the neurologic and functional score changes before and after acupuncture therapies.

MATERIALS AND METHODS

Subjects

A total of 100 traumatic spinal cord–injured patients with complete motor paralysis below the injury level were recruited into this study. Table 1 summarizes the subjects' characteristics. All the recruited patients received the necessary initial emergent treatments for SCI, which included surgical bone fusions and fixations for some patients. Fifty of the patients received additional acupuncture therapy, and these patients were regarded as the acupuncture group. For patients not requiring surgical interventions, acupuncture and rehabilitation therapies were initiated early at the emergency center and continued until the day of discharge. For patients requiring surgery, the aforementioned therapies were initiated after the patients were transferred back to ordinary wards. The other 50 patients without acupuncture therapy were regarded as the control group, and they only received necessary rehabilitation therapies.

The exclusion criteria were: patients who required mechanical ventilation and those with concomitant traumatic brain injury, peripheral nerve injury, loss of consciousness, and multiple bony fractures. All patients gave informed consent to participate in the study, which was performed according to the guidelines of the local ethics committee.

Evaluation of Patients

The neurologic status or score was assessed by the International Standards for Neurologic and Functional Classification of SCI as developed by the American Spinal Injury Association (ASIA). The neurologic score included sensory and motor examinations. For the sensory examination, each dermatome was tested for both sharp (pin-prick) and light-touch sensation. Sharp sensation was tested by using a disposable safety pin, and light touch was tested with cotton. The scale for sensory testing was from 0 to 2, with 0 as absent sensation and 2 as normal sensation. When all the dermatomal levels were tested bilaterally, a maximum score would be 112.

A total of ten myotomes were assessed bilaterally, with a manual muscle testing score of 0–5 per muscle group. The overall score range was from 0 to 100. The ASIA impairment scale was used for the determination of degree of completeness in

TABLE 1
Demographic data of acupuncture and control groups

	Acupuncture (n = 50)	Group Control (n = 50)	Group P Value
Age, yr	35.1 ± 13.0	34.7 ± 13.1	0.53
Sex, M/F	41/9	39/11	0.62
Level of lesion, quadriplegia/paraplegia	19/31	18/32	0.84
ASIA grade A/B	28/22	32/18	0.419
Duration of hospitalization, days	58.6 ± 17.1	57.1 ± 18.7	0.68

ASIA, American Spinal Injury Association.

injury. This scale closely parallels that of Frankel.

The functional status was assessed by using the Chinese version of the FIM™ instrument due to its high interrater reliability. All patients were evaluated by a well-trained nurse practitioner. FIM scores were constructed based on seven levels of function. The assessment defines 18 items within the following six areas of functioning: self-care, sphincter control, mobility, locomotion, communication, and social cognition. The scores may range from a low of 18 to a maximum of 126.

Acupuncture Protocol

Selected Acupoints. The acupoints of bilateral Hou Hsi (SI3) and Shen Mo (B62) (Fig. 1) were selected for acupuncture therapy. The Hou Hsi acupoint is located at the end of transverse crease of the fifth metacarpophalangeal joint when the hand is placed in a fisted position. Shen Mo is located at the feet, near the inferior lateral malleoli areas. Both acupoints are connected to the Governic meridian, which is related to the spinal cord as documented by traditional Chinese medicine.

Patients in the acupuncture group received electrical acupuncture therapy via the 4×5 cm^2 adhesive surface electrodes at the aforementioned bilateral acupoints. The HANS electro-acupuncture apparatus (Wearnes Technology, Singapore) was applied for stimulation. The frequency was set at 75 Hz, with a pulse duration of 200 μsec, and the magnitude of stimulation was set at 10 mV. Each treatment session was 30 min, with a total of five sessions per week.

Auricular Acupuncture. In addition to the Hou Hsi (SI3) and Shen Mo (B62) acupoints, acupuncture therapy to bilateral ears was also performed for patients in the acupuncture group. The auricular acupuncture was performed by using a small needle (1 mm in length) with a ring-tail, held in place by adhesive tape for 1 wk at the ear acupoint. Four acupoints related to the spinal cord were selected for stimulation at the antihelix, helix, and lower portion of the ear-back areas (Fig. 1). The small needles were changed every week.

Data Analysis

The FIM, sensory, and motor assessment data were gathered during initial admission to the rehabilitation ward, discharge from the hospital, and 1 yr after SCI. Statistical comparisons were performed based on these three time points. The SPSS software (SPSS, Chicago, IL) was used for statistical data analysis. Means were compared by the two-tailed t test or repeated measurements of the analysis of variance test. The repeated measurements of the analysis of variance test was confirmed by the post hoc Hermert test. The nonparametric FIM data were compared by using Wilcoxon's signed-rank test. Proportions were further compared by applying χ^2 tests. Statistical significance was set at $P < 0.05$.

RESULTS

During initial admission to the hospital, all the 100 acute SCI patients belonged to ASIA impairment scale A or B. They were matched for age, sex, level of injury, and ASIA impairment scale. Patients were randomly distributed to the acupuncture and control group, with 50 patients in each group (Table 1).

The neurologic status (ASIA sensory and motor scores) and functional status (FIM total score) of each group at the time of admission to rehabilitation ward, discharge from the hospital, and 1-yr postinjury follow-up examination are summarized in Table 2. In the acupuncture group, all the sensory, motor, and FIM scores improved significantly when examined on the day of discharge from the hospital and 1 yr after injury ($P < 0.05$). Whereas in the control group, only the motor score revealed significant improvement when at 1-yr postinjury follow-up ($P = 0.023$). In terms of the individualized area of sphincter function in the FIM score, the bladder control score was 3.02 ± 1.39 and the bowel control score was 3.42 ± 0.98 when examined at the 1-yr postinjury follow-up for the acupuncture group. In the control group, the bladder control score was 1.49 ± 1.35 and the bowel control score was 1.70 ± 1.47 when examined at the 1-yr follow-up. When both groups were compared, significant improvement in sphincter function was noted in the acupuncture group ($P = 0.001$).

The comparison of ASIA and FIM scores of both groups during the three different time points are summarized in Table 3. During initial admission to the rehabilitation ward, no significant difference in ASIA and FIM scores were noted. At the time of discharge and at the 1-yr postinjury follow-up, the acupuncture group revealed significant improvement in all the ASIA and FIM scores when compared with the control group ($P < 0.05$).

The ASIA impairment scale of all the patients are listed in Table 4. The most remarkable finding is that more patients in the acupuncture group improved to an ASIA grade of C or better when examined at the time of discharge and at 1-yr postinjury follow-up as compared with the control group ($P < 0.05$). The changes in the ASIA impairment scale of both groups during the three different time points are further illustrated in Figure 2.

DISCUSSION

Acupuncture has been used in traditional Chinese medicine to relieve pain and cure a variety of diseases for more than 2500 yr. There are 361 identified acupoints, and together they form a network of 14 channels, called the meridians. Through these meridi-

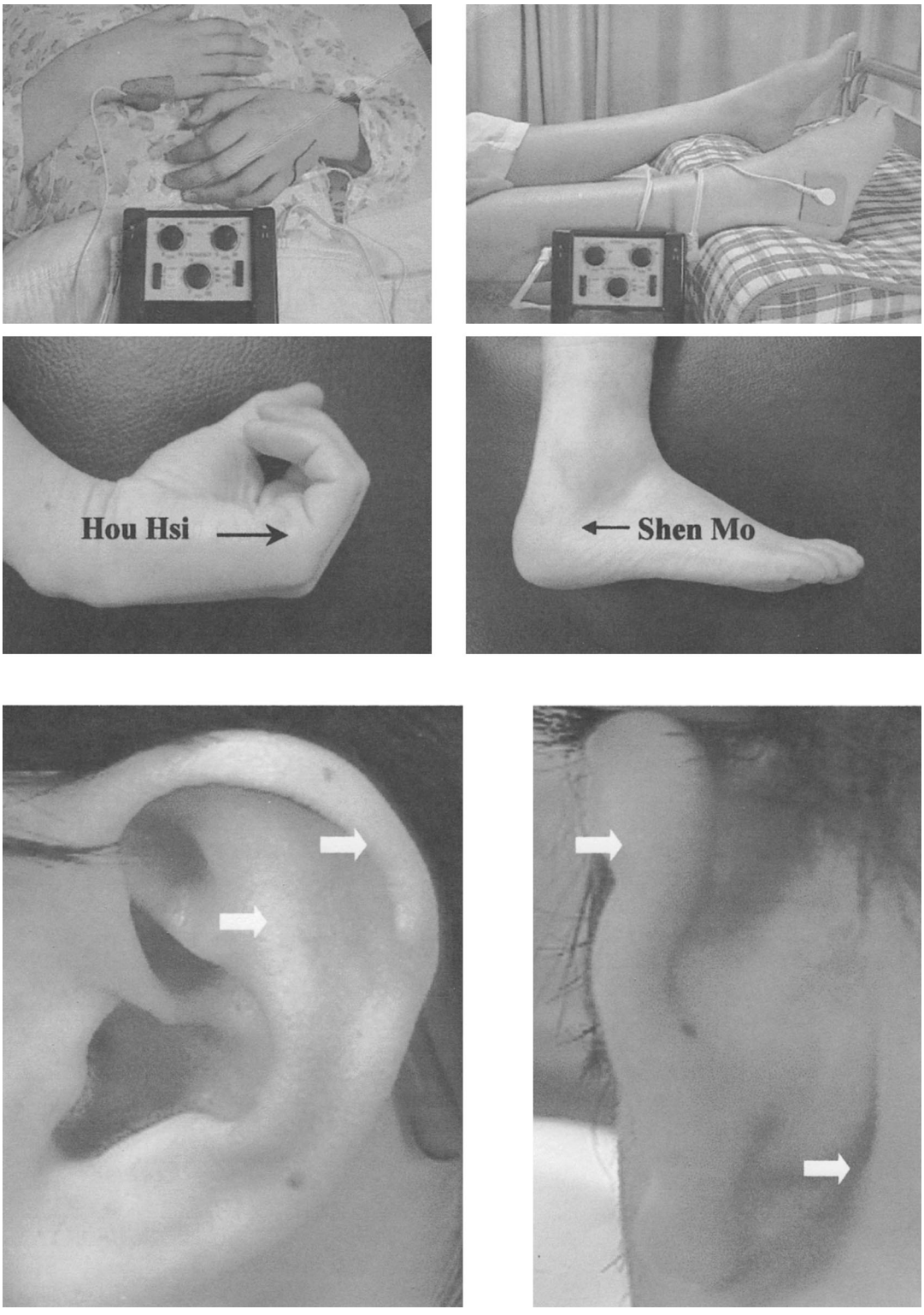

Figure 1: Selected acupoints for acupuncture therapy.

ans, the internal organs are believed to be interconnected with the superficial parts of the body. Acupuncture therapy has been shown to be effective in improving functional outcomes in hemiplegic stroke patients and paraplegic spinal cord–injured patients. Therapeutic trials of acupuncture therapy for neurogenic bladder of SCI patients also showed significantly shortened duration for bladder training.[8]

Acupuncture therapy is usually done by the insertion of thin metal needles to the acupoints, and this is followed by slow manual twisting action of the acupuncturist. The needles, once correctly inserted into the acupoints, can also be stimulated electrically. The de qi response is a prerequisite for effective acupuncture therapy. It is often described as an uncomfort-

TABLE 2
Comparison of neurologic and functional status of the twogroups during different time points

	ASIA Scores			FIM™
	Motor	PP Sensory	LT Sensory	Total Score
Acupuncture group				
Admission	41.0 ± 21.5	60.8 ± 27.7	63.0 ± 23.2	49.9 ± 13.1
Discharge	58.8 ± 21.4	80.0 ± 20.8	81.7 ± 20.3	75.8 ± 19.2
1-yr follow up	74.2 ± 23.7	90.0 ± 29.1	92.5 ± 27.8	106.9 ± 21.5
P value	0.000[a]	0.000[a]	0.000[a]	0.000[a]
Control group				
Admission	41.0 ± 17.7	59.1 ± 24.9	60.8 ± 24.4	47.7 ± 12.3
Discharge	45.1 ± 20.4	63.2 ± 27.4	64.1 ± 27.7	64.5 ± 19.7
1-yr follow up	52.3 ± 23.2	69.8 ± 26.8	70.5 ± 26.7	88.7 ± 24.0
P value	0.023[a]	0.128	0.179	0.000[a]

ASIA, American Spinal Injury Association; PP, pinprick; LT, light touch.
[a]$P < 0.05$.

able sensation, causing a numb, sore, or heavy feeling during needle twirling at the acupoint.[9,10] In our ASIA grade A and B SCI patients, sensory perception is absent caudal to the injury level. The usual de qi response could not be perceived by these patients. The application of needles might even be a noxious stimulus causing autonomic hyperreflexia, especially in patients with higher cord level injury. As a result, the alternative electrical acupuncture therapy through adhesive surface electrodes and auricular acupuncture therapy were applied to the patients.[7,11] Rehabilitation treatments were also performed on these patients in addition to the acupuncture therapies.

The mechanism of action provided by electrical acupuncture therapy is believed to be different than that of traditional therapeutic electrical stimulation. In electrical stimulation, muscles are stimulated. This can be observed through the twitching and contraction motions of the stimulated muscles. However, in electrical acupuncture therapy, stimulation is provided directly to the acupoint areas, not to the muscles nor the neuromuscular junction areas. As a result, the typical muscle contraction motions will not be observed during electrical acupuncture therapy.

In this study, the Hou Hsi (SI3) and Shen Mo (B62) were selected as

TABLE 3
Comparison of neurologic and functional status in the two groups during different time points

	ASIA Scores			FIM™
	Motor	PP Sensory	LT Sensory	Total Score
Admission				
Acupuncture group	41.0 ± 21.5	60.8 ± 22.7	63.0 ± 23.2	48.7 ± 13.1
Control group	41.0 ± 17.7	59.1 ± 24.9	60.8 ± 24.4	47.7 ± 12.3
P value	0.992	0.425	0.616	0.407
Discharge				
Acupuncture group	58.8 ± 21.4	80.0 ± 20.8	81.7 ± 20.3	75.8 ± 19.2
Control group	45.3 ± 20.4	63.2 ± 27.4	64.1 ± 27.7	64.5 ± 19.7
P value	0.002[a]	0.001[a]	0.000[a]	0.004[a]
1-yr follow up				
Acupuncture group	74.4 ± 23.7	90.0 ± 29.1	92.5 ± 27.8	106.9 ± 21.5
Control group	52.3 ± 23.2	69.9 ± 26.8	70.5 ± 26.7	88.7 ± 24.0
P value	0.000[a]	0.000[a]	0.000[a]	0.000[a]

ASIA, American Spinal Injury Association; PP, pinprick; LT, light touch.
[a]$P < 0.05$.

TABLE 4

Changes in American Spinal Injury Association (ASIA) impairment scale of both groups during three different time points

	Acupuncture Group					Control Group					
ASIA Grade	A	B	C	D	E	A	B	C	D	E	*P*
A											
Admission	28					32					1.0
Discharge	10	4	12	2	0	28	3	1	0	0	0.000
1-yr follow-up	8	3	10	2	5	27	2	3	0	0	0.000
B											
Admission		22					18				1.0
Discharge	0	0	9	12	1	0	6	7	5	0	0.003
1-yr follow-up	0	0	0	6	16	0	3	5	6	4	0.000
Total											
Admission	28	22	0	0	0	32	18	0	0	0	0.419
Discharge	10	4	21	14	1	28	9	8	5	0	0.000
1-yr follow-up	8	3	10	8	21	27	5	8	6	4	0.000

the acupoints for acupuncture therapy. The Hou Hsi (SI3) and Shen Mo (B62) acupoints belong to the Yang Ming meridian of the hands and feet, which are connected to the cervical spinal cord. The four auricular acupoints selected in this study were related to more levels of the spinal cord, which also included the lumbar cord level.[9]

As evident in our results, patients in the acupuncture group had significant motor, sensory, and FIM score improvements during the time of discharge and 1-yr postinjury follow-up as compared with the control group. The acupuncture group also had many patients improved to an ASIA grade of C or better. There can be numerous neurophysiologic factors contributing to the aforementioned improvements that are difficult to be proved clinically

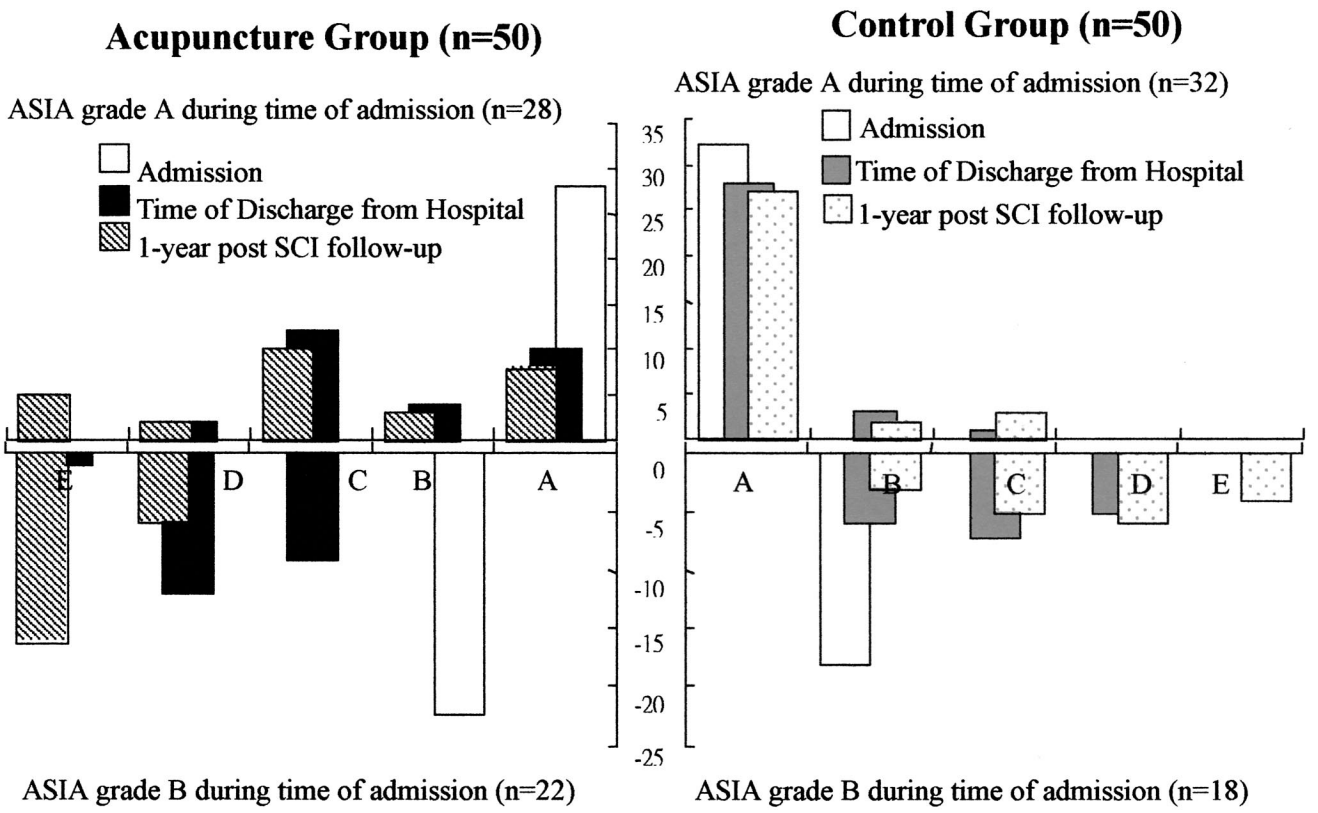

Figure 2: Changes in American Spinal Injury Association (*ASIA*) impairment scale of both groups during the three different time points. *SCI*, spinal cord injury.

and scientifically. Nevertheless, it is believed that acupuncture therapy through the correct acupoints and meridians in the acute SCI episode will assist in the minimization of posttraumatic cord shrinkage and sparing of the ventral horn neurons.[5,6] Even in the cases of complete SCI, Dimitrijevic et al.[12,13] and Sherwood et al.[14] proposed that some tracts are actually "spared" with intact continuity of white matter across the lesion site. However, these tracts may become electrophysiologically silent and even progress to cell death when cord injury is too severe.[15–19] Acupuncture therapy, when applied early in SCI, might hasten the healing process in these tracts.

The prognoses of neurologic and functional recoveries are known to be poor in ASIA grade A SCI patients. The study by Waters et al.[20] reported that functional and neurologic recovery after acute SCI seems to be better in patients with higher muscle power and a lower level of cord injury. However, our results revealed that with early acupuncture therapy, significant neurologic and functional recoveries can be achieved even in patients with ASIA grade A, absent muscle power, and higher cord injuries.

CONCLUSION

The use of concomitant auricular acupuncture and electrical acupuncture therapy through adhesive surface electrodes, when implemented early in acute SCI, can contribute to significant neurologic and functional recoveries in SCI patients with ASIA grade A and B. Therefore, acupuncture therapy may be considered as an effective alternative treatment strategy for SCI patients. With combined rehabilitation therapy, a higher quality treatment plan can thus be offered to SCI patients.

REFERENCES

1. Staas WE, Formal CS, Freedman MK, et al: *Spinal Cord Injury and Spinal Cord Injury Medicine: Rehabilitation Medicine Principles and Practice*, ed 3. Philadelphia, Lippincott-Raven, 1998, pp 1259–91

2. Wong MK, Chen CF, Lien IN: Evaluation of the result of rehabilitation for spinal cord injuries over a recent 10-year period. *J Formos Med Assoc* 1981;80:433–41

3. Lee MHM, Liao SJ;: Acupuncture in physiatry, in Kottke FJ, Lehmann JF (eds): *Krusens Handbook of Physical Medicine and Rehabilitation*, ed 4. Philadelphia, Saunders, 1990, pp 402–32

4. Bonnerman R: Acupuncture: The World Health Organization view. *World Health* 1979;31:24–29

5. Politis MJ, Korchinski MA: Beneficial effects of acupuncture treatment following experimental spinal cord injury: A behavioral, morphological, and biochemical study. *Acupunct Electrother Res* 1990;15:37–49

6. Ran C, Ba S, Liu X, et al: Acupuncture treatment of spinal paraplegia with acupoints selected, basing on neuroanatomy. *World J Acupunct Mox* 1992;2:3–9

7. Wong AMK, Su TY, Tang FT, et al: Clinical trial of electrical acupuncture on hemiplegic stroke patients. *Am J Phys Med Rehabil* 1999;78:117–22

8. Cheng PT, Wong MK, Chang PL: A therapeutic trial of acupuncture in neurogenic bladder of spinal cord injured patients: A preliminary report. *Spinal Cord* 1998;36:476–80

9. Tsay RC: *Textbook of Chinese Acupuncture Medicine: General Introduction to Acupuncture*. Wappinger Falls, Association of Chinese Medicine and East-West Medical Center, 1974, vol 1, pp, 40–52

10. Wu D: Acupuncture and neurophysiology. *Clin Neurol Neurosurg* 1990;92:13–25

11. Johansson K, Kindgren I, Windener H, et al: Can sensory stimulation improve the functional outcome in stroke patients? *Neurology* 1993;43:2189–92

12. Dimitrijevic MR, Faganel J, Lehmkuhl D, et al: Motor control in man after partial or complete spinal cord injury. *Adv Neurol* 1983;39:915–26

13. Dimitrijevic MR: Residual motor function in spinal cord injury. *Adv Neurol* 1988;47:138–55

14. Sherwood AM, Dimitrijevic MR, Mckay WB: Evidence of subclinical brain influence in clinically complete spinal cord injury: Discomplete SCI. *J Neurol Sci* 1992;110:90–8

15. Kakulas BA: A review of the neuropathology of human spinal cord injury with emphasis on special features. *J Spinal Cord Med* 1999;22:119–24

16. Kakulas BA: The applied neuropathology of human spinal cord injury. *Spinal Cord* 1999;37:79–88

17. Little JW, Ditunno JF, Stiens SA, et al: Incomplete spinal cord injury: Neuronal mechanisms of motor recovery and hyperreflexia. *Arch Phys Med Rehabil* 1999;80:587–97

18. Murray M: Strategies and mechanisms of recovery after spinal cord injury. *Adv Neurol* 1997;72:219–25

19. Lu J, Waite P: Advances in spinal cord regeneration. *Spine* 1999;24:926–30

20. Waters RL, Akins R, Yakura J, et al: Functional and neurological recovery following acute spinal cord injury. *J Spinal Cord Med* 1998;21:195–9