Effect of Ultrasound Thermotherapy in Mild to Moderate Carpal Tunnel Syndrome

Krisna Piravej MD*,
Jariya Boonhong MD*

** Department of Rehabilitation Medicine, Faculty of Medicine, Chulalongkorn University*

Objective : *To investigate the efficacy of low intensity ultrasound thermotherapy, a conservative option of treatment of mild to moderate carpal tunnel syndrome (CTS).*
Design : *Prospective experimental, placebo- controlled, before-after treatment trial.*
Setting : *King Chulalongkorn Memorial Hospital, Outpatient Clinic and Electrodiagnostic Laboratory, Department of Rehabilitation Medicine.*
Patients : *Eighteen women, 30 hands who had clinical and electrophysiologic evidence of mild to moderate CTS.*
Interventions : *Patients of CTS were divided into two groups; A and B of 15 hands by random sampling. Group A was given placebo and continuous ultrasound therapy with the intensity of 0.5 W/cm^2 applied to the palmar carpal tunnel for 10 minutes. Group B was given Diclofenac 75 mg/day in divided doses and sham ultrasound. The ultrasound was applied 5 days a week for 4 weeks.*
Outcome measures : *Each patient was clinically and electrophysiologically evaluated before and after treatment.*
Results : *There were statistically significant improvements ($p < 0.05$), in the clinical parameters of both groups after treatment. In the electrophysiologic study, the median SNAP amplitude was increased significantly after the treatment in ultrasound group (group A). When both groups were compared, group A had significant difference in increasing of median SNAP amplitude after treatment.*
Conclusion : *The therapeutic efficacy of low intensity ultrasound thermotherapy was satisfied for mild to moderate CTS. However, the electrophysiological changes after ultrasound treatment need further investigation.*

Keywords*: Ultrasound thermotherapy, Carpal tunnel, SNAP amplitude.*

J Med Assoc Thai 2004; 87 (Suppl 2): S100-6
e-Journal: *http://www.medassocthai.org/journal*

Carpal tunnel syndrome (CTS) is the most frequently encountered peripheral entrapment neuropathies. It affects 0.1% of the general population and as many as 15% of workers in high-risk industries [1, 2]. Entrapment may occur where a nerve passes through a confined osseofibrous tunnel or a fibrous tissue slit. The situation is present in CTS as the median nerve, with the long flexor tendons; its course runs through the carpal tunnel at the wrist. Pressure can build up to a critical level by swolling the accompanying tendons affected by repetitive injuries [3]. In general, women are more prone to be afflicted than men, and the syndrome can be bilateral, though of different intensity and duration. Usually, CTS has a gradual onset related to hyperesthesia, tingling over the surface of the thumb, index, middle fingers, and the lateral half of the palm. This may be followed by pain and clumsiness of the affected hand due to the weakness of the thenar muscles. However, acute deterioration can be closely associated with a recent change to more strenuous manual activities, especially those who are involved with repetitive motions of the wrists [4-6]. This acute CTS is manifested by electrophysiological conduction block of sensory, motor or both fiber types at the carpal tunnel [3]. Though surgery by carpal tunnel release is the definite treatment for CTS, not all patients respond to surgery [7]. Medical and various non-invasive managements can be very useful alternatives, especially, in mild to moderate symptoms. However, these conservative treatments, such as the local steroid injection or the use of oral steroid drugs also have their own limitations and complications. Application of heat has been recommended for the treatment of peripheral neuropathy [8,9] and it is well accepted that ultrasound thermotherapy is a safe and commonly applied deep-heat modality in physical medicine. In addition, Lubinska and Olekiewicz [10] reported that the rate of nerve regenera-

Correspondence to : Piravej K. Department of Rehabilitation Medicine, Faculty of Medicine, Chulalongkorn University, Bangkok 10330, Thailand.

tion could be influenced by temperature. Hong et al [11] found that in bilateral tibial nerve compression in rats, a dose of 0.5 W/cm^2 at 1 MHz of ultrasound thermotherapy could improve the recovery rate of nerve conduction, while an intensity of 1 W/cm^2 caused the opposite effect. They concluded that a low dose of ultrasound might facilitate recovery of experimental acute compression neuropathy. The mechanical and heating properties of ultrasound have been reported to affect the ability of nerve fibers to propagate action potentials, although the physiological mechanisms were not clear [12]. In addition, continuous application of ultrasound to healthy functioning nerves was found to increase sensory nerve conduction velocity (NCV) [13-15] but could either increase or decrease motor NCV at different doses [16-18]. Ebenbichler et al assessed the efficacy of ultrasound treatment of 1.0 W/cm^2 at 1MHz for mild to moderate idiopathic CTS. Their results suggested that there were satisfying short to medium term effects in those patients [19]. Oztas et al investigated the overall effect of repeated ultrasound treatment of 1.5 W/cm^2 and 0.8 W/cm^2 in CTS. Their study demonstrated the efficacy of ultrasound therapy in CTS was comparable to placebo ultrasound in relieving symptoms and ultrasound probably gave negative effect on motor nerve conduction [20]. Thus, the evidence that ultrasound treatment may have benefit in CTS is still uncertain [21,22]. In the present study the authors investigated the efficacy of low intensity ultrasound thermotherapy as an option of non-invasive management of mild to moderate degree of CTS.

Objective

The present study was designed to investigate therapeutic efficacy of low intensity ultrasound thermotherapy on mild to moderate idiopathic CTS compared to the use of non-steroidal anti-inflammatory drug (Diclofenac 75 mg/day).

Materials and Method

Patients

Twenty-six patients whose ages ranged from 33 to 68 years or 30 hands with clinical and electrophysiologic evidences of mild to moderate idiopathic CTS were studied. Criteria for the diagnosis of CTS were as follows: history: (1) dull, aching discomfort in the hand, forearm or upper arm; (2) progressive clumsiness and weakness in the hands associated with hypesthesia and tingling in the distribution of the median nerve distal to the wrist joint; (3) pain at night, awakened by burning pain in the thumb, index and long fingers; physical examination: (1) hypoesthesia, either objective or subjective, restricted to the median distribution in the hand; (2) a positive wrist flexion test; (3) Tinel's sign, a tingling sensation radiating out into the hand, produced by light percussion over the median nerve at the wrist. The inclusion criteria for the study were: (1) clinical manifestation of CTS of less than twelve months; (2) musculoskeletal problems or specific predisposing factors, such as rheumatic diseases, diabetes mellitus, cervical spondylosis, acute trauma and pregnancy were excluded; (3) no treatment for at least one month; (4) no local corticosteriod injection during the last three months; (5) no serious co-existing medical condition that may prohibit electrophysiological test during the study; (6) no allergy or contraindication for Diclofenac and ultrasound therapy; (7) no muscle atrophy, anesthesia or intractable pain due to CTS; (8) electrophysilogic test showed the presence of median nerve sensory and motor responses with sensory distal latency (SDL) longer than 2.8 msec but not more than 4.50 msec, sensory nerve action potential (SNAP) amplitude exceeding 10 uv, median-ulnar mixed nerve latency difference longer than 0.5 msec, motor distal latency (MDL) longer than 4.2 msec but not more than 6.50 msec and compound muscle action potential (CMAP) amplitude not less than 5.0 mv; (9) electromyograhy of the abductor pollicis brevis (APB) muscle showed no spontaneous activity or markedly reduce firing frequency; (10) the patient accepted the study and signed the informed consent. A physician simple randomed the patients into 2 groups by drawing a paper which was labled A or B of 15 cases without replacement. If a patient had CTS of both hands, they would be assigned in the same group. Group A was given placebo and continuous ultrasound therapy with intensity of 0.5 W/cm^2 applied to palmar carpal tunnel for 10 minutes. Group B was given Diclofenac 75 mg/day in a divided dose and ultrasound 0.0 W/cm^2. The objectives and methods of the study were explained to each patient before receiving their informed consent. The study was approved by the ethics committee of our hospital.

Methodology

Each patient was interviewed and fully documented regarding the type, severity and frequency of the symptoms, followed by electrophysiological test for baseline data.

Categorization of symptoms

All patients were examined by the impartial physician who had not involvement with treatment

assignment. The symptoms were categorized as follows: severity of pain was recorded by the patients both before and after the treatment. A 100-mm horizontal visual analog scale (VAS) was used, with one end labeled "no pain" and the other unbearable pain.

Presence of symptoms at night and/or day, pain and/or paresthesia were scored as follows: 0 = no symptom (only after treatment), 1 = mild (noctural and/or diurnal paresthesia), 2 = moderate (nocturnal pain and paresthesia) and 3 = severe (nocturnal and diurnal pain and paresthesia).

Frequency of awakening from symptoms at night per week was scored as follows: 0 = never wake up; 1= 1-2 times a week; 2 = 3-6 times a week; and 3 = 7 times or more.

Electrophysiological evaluation

The electrophysiological tests were performed by the same physician, who did not involve with treatment assignment. The electromyography equipment used was the Medelec Sapphire Premire. Subjects were examined in a sitting position. The skin temperature was kept constant at about 33-34 °c. The conduction of the median sensory nerve was studied antidromically from the second digit to the wrist with a distance of 13 cm. For median motor nerve conduction study, the compound muscle action potentials of the APB muscle were recorded. The median nerve at the wrist 8 cm. proximal to the recording electrode was stimulated supramaximally. The sweep speed velocity for sensory testing was set at 10 msec, whereas for motor testing was set at 50 msec, and duration of stimulus was 0.1 msec in both studies. The voltage was increased until action potentials reached maximal amplitude. The electrophysiologic evaluations included median SDL, SNAP amplitude, MDL and CMAP amplitude.

Ultrasound Treatment

The continuous ultrasound therapy in circular fashion was performed with intensities of 0.5 W/cm^2 in groups A and 0.0 W/cm^2 (without energy emission) in group B. A Nemectroson 400 ultrasound machine with a frequency of 1 MHz and a 2.5 cm diameter soundhead, in conjunction with a coupling media of Aquasonic ultrasound transmission gel, were used. The ultrasound head and transmission gel were at room temperature before treatments. The size of the sonation area was approximately 2 cm x 4 cm. The ultrasound was applied to the palmar carpal tunnel area, which expanded from the wrist crease to the palmar region and covered an area of 4 to 4.5 cm in length and 3.5 to 4.0 cm in width. The ultrasound therapy lasted 10 minutes per session, 5 days a week, for 4 weeks, and patients were unaware of the treatment groups.

Clinical and electrophysiologic evaluations were performed before and within five days after the 4 weeks of treatment, so that the interval between evaluation was 25 to 30 days. Neither medication nor other physical therapy was allowed during the present study.

Statistical Analysis

All the parameters of all subjects in each group were calculated for mean, standard deviations and 95% CI. The statistical methods used for analyzing data were:

1. The paired t-test was used to compare pain VAS and electrophysiologic parameters (SDL, SNAP amplitude, MDL and CMAP amplitude) before and after treatment in each group but if the data was not normal distribution, nonparametric statistics will be used instead.

2. The unpaired t-test was used to compare pain VAS and electrophysiologic parameters (SDL, SNAP amplitude, MDL and CMAP amplitude) between treatment groups but if the data was not normal distribution, non-parametric statistics will be used instead.

3. Mann-Whitney U test was used to compare night/day pain-paresthesia score and frequency of awakening before and after treatment in each group and to compare between treatment groups.

* $p < 0.05$ is considered statistically significant.

Results

Eighteen women, 30 hands with a mean age of 46.97 $\pm$ 8.37 years were recruited in the present study. The mean duration of their symptoms was 6.53 $\pm$ 4.33 months. They were simple randomized into two groups, each with 15 hands of mild to moderate idiopathic CTS. The demographic characteristics of patients in each group are shown in Table 1. The clinical

Table 1. Demographic data of patients

Group	Treatment	No. of Patients	No. of CTS Hands	Age Range (Mean $\pm$ SD)	Duration of symptoms, month (Mean$\pm$SD)
A	US 0.5 W/cm^2 + placebo	10	15	33-68 49.07$\pm$8.88	1-12 6.40$\pm$4.50
B	US 0.0 W/cm^2 + Diclofenac 75 mg/day	8	15	33-57 44.87$\pm$7.55	1-12 6.67$\pm$4.32

Abbreviation: US, ultrasound

and electrophysiologic parameters before treatment between group A and group B were no statistically significant difference (Table 2). None of the patients reported progressive worsening in their symptoms or reluctance to receive therapy during the present study. On comparing the severity of symptoms, there was statistically significant improvement regarding the severity of pain, paresthesia and frequency of awakening before and after treatment in each group. However, there was no statistically significant difference observed between the groups ($p > 0.05$) (Table 3). The electrophysiological parameters were also compared before and after treatment in each group (Table 4). After treatment, the Median SNAP was increased significantly in group A. On comparing the groups, there was significantl difference in increasing median SNAP amplitude after treatment between group A and B.

Discussion

"Carpal tunnel syndrome" is now applied to compression neuropathy of the median nerve at the wrist. An increase in pressure in the carpal tunnel is usually caused by non-specific flexor tenosynovitis [23]. Chronic focal compression of a nerve trunk can cause focal demyelination by mechanical stress deforming the myelin lamellae. Some authors [24,25] believed that ischemia of the median nerve was the pathogenic cause of CTS which resulted in intermittent paresthesia at night or with wrist flexion [4]. CTS is often observed bilaterally. Treatments include medications such as nonsteroidal anti-inflammatory drugs, diuretics, splints, steroid injections into the carpal tunnel, and surgical release of the flexor retinaculum [6]. In the present study all patients were women with a mean age of 46.97 ± 8.37 years. Most of them (73.1%) had bilateral involvement. The authors investigated the therapeutic efficacy of low intensity ultrasound therapy as a conservative treatment agent in CTS. After 4 weeks, 5 days/week of 10 minutes' daily continuous ultrasound therapy and Diclofenac 75 mg/day, all three clinical parameters due to pain, paresthesia and frequency of awakening showed significant improvement in both treatment groups. The findings of improvement were similar to a previous report by Oztas et al [20]. He studied the effect of ultrasound therapy with intensities of 0.8 W/cm^2 and 1.5 W/cm^2 compared to placebo ultrasound as a conservative treatment in CTS. The clinical parameters at the end of treatment showed statistically significant improvement in all groups. He suggested that placebo ultrasound may cause pain relief by its local massage effects. Ebenbichler et al [19] reported the efficacy of 1 MHz, 1.0 W/cm^2 ultrasound treatment for mild to moderate CTS compared with sham ultrasound. Results suggested there were satisfying short to medium term effects due to ultrasound treatment. Although the analgesic effect of ultrasound thermotherapy is well known, its mechanism is not clearly understood. Well [26] suggested that it might be associated with a reduction of the thermal gradient through the skin since hyperesthesia is associated with an increase of this gradient in either direction. Phalen [4] believed that localized ischemia of the median nerve may be associated with compression within the carpal tunnel. The rapid disappearance of paresthesia and pain after section of the transverse carpal ligament is consistent with temporary ischemia. In the case of long-continued severe compression, the ischemic changes in the nerve may be permanent. Tarzer [27] found vasomotor imbalance a prominent feature in fifteen of twenty-five hands with CTS, as manifested by significant sensi-

Table 2. Comparison of the clinical & electrophysiologic parameters before treatment between group A and group B

Parameters	Group A (US 0.5 W/cm^2 + placebo)	Group B (US 0.0 W/cm^2 + Diclofenac 75 mg/d)	p Value	95% CI
Clinical Parameters:				
Pain VAS	2.93±3.45	2.31±2.37	0.57	-1.59, 2.83
Night pain/paresthesia	1.47±0.83	1.53±0.92	0.82	-
Frequency of awakening	0.80±1.15	1.07±1.22	0.49	-
Electrophysiologic Parameters:				
SDL (msec)	3.17±0.46	3.58±0.42	0.05	-0.74, 0.08
SNAP amplitude (uV)	46.12±18.99	52.29±22.94	0.42	-21.92, 9.58
MDL (msec)	4.26±0.69	4.85±0.67	0.05	-1.10, 0.07
CMAP amplitude (mV)	11.31±2.88	10.93±3.05	0.73	-1.85, 2.59

Abbreviation: VAS, visual analog scale; SDL, sensory distal latency; SNAP, sensory nerve action potential; MDL, motor distal latency; CMAP, compound muscle action potential

Table 3. Comparison of the clinical parameters before and after treatment

Clinical parameters	Group A (US 0.5 W/cm² + placebo)	Group B (US 0.0 W/cm² + Diclofenac 75 mg/d	Mean difference BT& AT Group A & B
Pain VAS			
BT	2.93±3.45	2.31±2.37	A: 1.90±2.53
AT	1.03±1.53	1.23±2.14	B: 1.09±1.10
p Value	0.01*	0.002*	0.71
95% CI	0.50, 2.3	0.47, 1.69	-0.64, 2.27
Night pain/paresthesia			
BT	1.47±0.83	1.53±0.92	A: 0.93±0.97
AT	0.53±0.64	0.60±0.63	B: 0.93±0.88
p Value	0.00*	0.001*	0.89
95% CI	-	-	-
Frequency of awakening			
BT	0.80±1.15	1.07±1.22	A: 0.53±1.06
AT	0.27±0.80	0.20±0.56	B: 0.87±1.12
p Value	0.04*	0.01*	0.36
95% CI	-	-	-

Abbreviations: BT, before treatment; AT, after treatment; VAS, visual analog scale; * Statistically significance

Table 4. Comparison of the electrophysiologic parameters before and after treatment

Electro-physiologic parameters	Group A (US 0.5 W/cm² + placebo)	Group B (US 0.0 W/cm² + Diclofenac 75 mg/d	Mean difference BT& AT Group A & B
SDL			
BT	3.17±0.46	3.58±0.42	A: -0.07±0.22
AT	3.24±0.57	3.59±0.51	B: -0.01±0.41
p value	0.21	0.94	0.58
95% CI	-0.19, 0.004	-0.23, 0.22	-0.31, 0.18
SNAP amplitude			
BT	46.12±18.99	52.29±22.94	A: -15.21±20.04
AT	61.33±30.65	48.22±25.67	B: 4.06±22.08
p value (BT/AT)	0.01*	0.49	0.02*
95% CI	-26.31, -4.11	-8.17, 16.3	-35.0, -3.49
MDL			
BT	4.26±0.69	4.85±0.67	A: -0.21±0.40
AT	4.47±0.69	4.74±25.67	B: 0.11±0.70
p value (BT/AT)	0.06	0.56	0.13
95% CI	-0.43, 0.01	-0.28, 0.50	-0.74, 0.11
CMAP amplitude			
BT	11.31±2.88	10.93±3.05	A: -0.65±1.81
AT	11.96±3.08	10.59±3.19	B: 0.34±2.00
p value (BT/AT)	0.19	0.52	0.16
95% CI	-1.65, 0.35	-0.76, 1.5	-2.4, 0.43

Abbreviation: SDL, sensory distal latency; SNAP, sensory nerve action potential; MDL, motor distal latency; CMAP, compound muscle action potential; * Statistically significance

tivity to cold. The beneficial effect of ultrasound for ischemic pain can be explained by increased blood flow in deep tissues, not by the heating effect but also by a "neurotrophic" mechanism which alters nervous regulation of local blood flow [28]. Numerous clinical studies have described the effectiveness of ultrasound in relieving pain of different types of musculoskeletal disease. Ultrasound has been shown to increase the pain threshold in human subjects similar to the level produced by raising tissue temperature by other means [29]. There is an inverse relationship between fiber size and sensitivity to ultrasound: the smallest C fibers are more sensitive and the large A fibers are less affected [30]. This selective absorption by smaller fibers may allow a decrease in pain transmission. Symptomatic improvement could be due to change in sympathetic fibers. Since the standard technique of nerve conduction studies give only information on the largest and fastest conducting myelinated nerve fibers; therefore the authors could not detect any change in the electrophysiological function of small, unmyelinated nerve fibers.

The electrophysiological parameter in the present study showed a significant increase of median SNAP amplitude after ultrasound thermotherapy treatment in group A. The increase of median SNAP amplitude after treatment in the ultrasound group was of significant difference when compared with the control group. Oztas et al reported the effect of ultrasound intensities 0.8 W/cm² and 1.5 W/cm² in CTS when comparing electrophysiological parameters before and after treatment and among the study and the placebo groups [20]. The result did not reveal any statistically significant difference ($p > 0.05$). However they did not study the amplitude changes before and after treatment. Ebenbichler [19] reported significant changes of electroneurographic variables: decreased motor distal latency and increased sensory nerve conduction velocity after ultrasound treatment. Dean et al. demonstrated the effect of ultrasound 1.5 W/cm² applied over the area of the lateral cutaneous branch of radial nerve in healthy subjects for 5 minutes at a frequency of 1 MHz continuous wave. The speed of sensory nerve conduction increased significantly but amplitude and duration of the nerve action potentials did not change significantly following sonation. Halle et al [14] also found linear relationship between subcutaneous temperature and an increase in sensory NCV when ultrasound was applied to the forearm of healthy adults for 5-20 minutes at an intensity of 1.0 W/cm². Their results support the thermal effect of ultrasound on the sensory nerve. Kramer[31] reported that ultrasound effects on

motor NCV were intensity dependent. Motor NCV may increase or decrease depending on ultrasound intensity, duration and tissue temperature. Nerve conduction can be temporarily blocked by heat application or by the rise of temperature, which was the result of absorption of ultrasound energy. Conduction in peripheral nerves can be blocked reversibly or irreversibly by focused ultrasound in appropriate dosages. Several studies on animals [32] and patients [33] with multiple sclerosis demonstrated evidences of reversible conduction block with increased temperature in demyelinated fibers. Zankel [20] suggested that lowering motor NCV in clinical doses might be due to change in the rate of exchange of transmembranal electrolytes in which the micro-massage action (mechanical) plays a major role. The decrease of NCV caused by high-dose ultrasound treatment may also be reversible up to 30 minutes after treatment. An injured nerve may be seen more sensitive to thermally induced conduction blockage due to reduced safety factor [32]. In an experimental study by Davis and Jacobbon [33], it was shown that there was increased susceptibility to thermally induced conduction block in pressure-injured and demyelinated nerve. In another study, Hong [10] reported a reversible conduction block as a result of acute ultrasound treatment in patients with painful peripheral neuropathy but not in painless peripheral neuropathy. Since the underlying pathology in CTS is focal demyelination caused by prolonged compression, the demyelinated part of the median nerve probably was more sensitive to the ultrasound treatment. According to Rasminsky, at less severely affected internodes an increased temperature caused a reduction in internodal conduction time, as at normal internodes. The patients in the present study were mild to moderately affected, and the authors were able to get all the responses after the treatment, the authors supposed that there was no irreversible conduction block. However, the significance of electrophysiologic changes in our study were not so strongly suggestive due to large 95% CI. This may be caused by small sample size and limitation of randomization.

Conclusion

The present findings suggested that low intensity ultrasound thermotherapy might have a therapeutic effect on mild to moderate idiopathic CTS. It can be used as a conservative treatment in mild to moderate CTS.

Suggestions for Further Work

Since the number of subjects in the present study was rather small thus the electrophysiological changes after ultrasound application did not strongly show significant difference and a longer-term follow-up need further investigation. It might be helpful to determine the appropriate dosage and observing acute and chronic effects of ultrasound on compression neuropathy.

Acknowledgement

The authors wish to express appreciation to the Asahi Glass Foundation, Japan and Faculty of Engineering, Chulalongkorn University for supporting this study.

References

1. Loslever P, Ranaivosoa A. Biomechanical and epidemiological investigation of carpal tunnel syndrome at workplaces with high risk factors. Ergonomics 1993; 36: 537-55.
2. Masear VR, Hayes JM, Hyde AG. An industrial cause of carpal tunnel syndrome. J Hand Surg (AM) 1986; 11: 222-7.
3. Kopell HP, Goodgold J. Clinical and electrodiagnostic features of carpal tunnel syndrome. Arch Phys Med Rehab 1968; 49: 371-5.
4. Phalen GS. The carpal tunnel syndrome. Bone and Joint Surgery (AM) 1966; 48A: 211-28.
5. Gordon C, Lubbers LM, Mc Cosker SP. Carpal tunnel syndrome. Phys Med Rehab:State Art Rev1992; 6: 223-32.
6. Phalen GS. Reflections on 21 years' experience with the carpal tunnel syndrome. JAMA 1970; 212: 1365-7.
7. O'Malley MJ, Evanoff M, Terrono AL, Millender LH. Factors that determine reexploration treatment of carpal tunnel syndrome. J Hand Surg (Am) 1992; 17: 638-41.
8. Hallet M, Tandon D, Berardelli A. Treatment of peripheral neuropathies. J Neurol Neurosurg Psychiatry 1985; 48: 1193-207.
9. Sunderland S. Nerves and nerves injuries. 2nd ed.NewYork, Churchill, Livingstone 1978: 493-8.
10. Lubinska L, Olekiewicz M. The rate of regeneration of amphibian peripheral nerves at different temperatures. Acta Biol Ep 1950; 15: 125-45.
11. Hong C-Z, Lin HH, Yu J. Ultrasound thermotherapy effect on the recovery of nerve conduction in experimental compression neuropathy. Arch Phys Med Rehab 1988; 69: 410-4.
12. Currier DP, Greathouse D, Swift T. Effect of ultrasound on sensory nerve conduction. Arch Phys Med Rehab 1978; 59: 181-5.
13. Lehmann JF, de Lateur BJ. Therapeutic heat. In: Lehmann JF, editor. Therapeutic heat and cold. 3rd ed. Baltimore (MD). William&Wilkins 1982: 404-562.
14. Halle JS, Scoville CR, Greathouse DG. Ultrasound's effect on the conduction latency of the superficial radial nerve in man. Phys Ther 1981; 61: 345-50.
15. Currier DP, Kramer JF. Sensory nerve conduction: heating effects of ultrasound and infrared. Physiother Can 1982; 34: 241-6.
16. Madsen PW, Gesten JW. Effect of ultrasound on conduction velocity of peripheral nerves. Arch Phys Med Rehab 1961; 42: 645-9.

17. Farmer WC. Effect of intensity of ultrasound on conduction of motor axons. Phys Ther 1968; 48:1233-7.
18. Zankel HT. Effect of physical agents on the motor conduction velocity of the ulnar nerve. Arch Phys Med Rehab 1966; 47: 787-92.
19. Ebenbichler GR, Resch KL, Nicolakis P, Wiesinger GF, Uhl F, Ghanem AH, Fialka V. Ultrasound treatment for treating the carpal tunnel syndrome: randomized "sham" controlled trial. BMJ 1998; 316: 731-5.
20. Oztas O, Turan B, Bora I. Ultrasound therapy effect in carpal tunnel syndrome. Arch Phys Med Rehab 1998; 79: 1540-4.
21. Wilson JK, Sevier TL. A review of treatment for carpal tunnel syndrome. Disabil Rehabil 2003; 25:113-9.
22. Goodyear-Smith F, Arroll B. What can Family Physicians offer patients with carpal tunnel syndrome other than surgery? A systemic review of nonsurgical management. Ann Fam Med 2004; 2: 267-73.
23. Gelberman RH, Hergenroeder PT, Hargens AR, Lundborg GN, Akeson WH. The carpal tunnel syndrome. A study of carpal canal pressures. J Bone Joint Surg (Am) 1981; 63: 380-3.
24. Gilliatt RW, Wilson TG. A pneumatic-tourniquet test in the carpal tunnel syndrome. Lancet 1953; 2: 595-7.
25. Kremer M, Gilliatt RW, Golding JSR, Wilson TG. Acroparaesthesia in carpal tunnel syndrome. Lancet 1953; 2: 590-5.
26. Wells HS. Temperature equalization for the relief of pain. An experimental study of the relation of thermal gradients to pain. Arch Phys Med Rehab 1947; 28: 135.
27. Tanzer RC. The carpal tunnel syndrome. A clinical and anatomical study. J Bone Joint Surg 1959; 41-A: 626-34.
28. Rubin D, Magovern G. Application of ultrasound to experimentally induce neuromas in dogs. Arch Phys Med 1957; 38: 377.
29. Binder A, Hodge G, Greenwood AM, Hazleman BL. Is therapeutic ultrasound effective in treating soft tissue lesion? BMJ 1985; 290: 512-4.
30. Young RR, Henneman E. Reversible block of nerve conduction by ultrasound. Arch Neurol 1961; 4: 83-9.
31. Kramer J.F. Sensory and motor nerve conduction velocities following therapeutic ultrasound. Aust J Physiother 1987; 33: 235-43.
32. Rasminsky M. The effects of temperature on conduction in demyelinated single nerve fibers. Arch Neurol 1973; 28: 287-9.
33. Davis FA, Jacobson S. Altered thermal sensitivity in injured and demyelinated nerve. J Neurol Neurosurg Psychiatry 1971; 34: 551-61.

ผลของ Ultrasound thermotherapy ในการรักษาภาวะเส้นประสาทมีเดียนถูกกดรัดบริเวณอุโมงค์ข้อมือ ในระยะรุนแรงน้อยถึงปานกลาง

กฤษณา พิรเวช, จริยา บุญหงษ์

วัตถุประสงค์ *: เพื่อศึกษาผลของ Ultrasound thermotherapy ในการรักษาภาวะเส้นประสาทมีเดียนถูกกดรัดบริเวณอุโมงค์ข้อมือในระยะรุนแรงน้อยถึงปานกลาง*

รูปแบบการศึกษา *: การศึกษาเชิงทดลองแบบไปข้างหน้า*

สถานที่ที่ทำการศึกษา *: แผนกผู้ป่วยนอก และห้องตรวจไฟฟ้าวินิจฉัย ฝ่ายเวชศาสตร์ฟื้นฟู โรงพยาบาลจุฬาลงกรณ์*

ประชากรตัวอย่าง *: ผู้ป่วยที่ได้รับการวินิจฉัยทางคลินิก และการตรวจไฟฟ้าวินิจฉัย ว่ามีภาวะเส้นประสาทมีเดียนถูกกดรัดบริเวณอุโมงค์ข้อมือ ในระยะรุนแรงน้อย ถึงระยะปานกลาง จำนวน 18 คน ทั้งหมด 30 มือ*

วิธีการศึกษา *: แบ่งผู้ป่วยทั้งหมดเป็น 2 กลุ่ม ๆ ละ 15 มือ โดยวิธีสุ่ม (simple randomized) กลุ่มแรกให้การรักษาโดยยาหลอก (placebo)และ continuous ultrasound 0.5 W/cm^2 กลุ่มที่2 ให้ยา Diclofenac 75 mg/day และ continuous ultrasound 0.0 W/cm^2 (sham) ตำแหน่งที่ให้ ultrasound คือบริเวณฝ่ามือเหนือ carpal tunnel โดยให้นานครั้งละ 10 นาที จำนวน 5 ครั้ง/สัปดาห์ นาน 4 สัปดาห์ ผู้ป่วยทั้งหมดจะได้รับการประเมินอาการทางคลินิก และการตรวจไฟฟ้าวินิจฉัยทั้งก่อน และหลังการรักษา*

ผลการศึกษา *: ผู้ป่วยทั้ง 2 กลุ่มมีอาการทางคลินิกดีขึ้นหลังจากได้รับการรักษาอย่างมีนัยสำคัญทางสถิติ ส่วนผลการตรวจทางไฟฟ้าวินิจฉัยหลังได้รับการรักษา พบว่าผู้ป่วยกลุ่มที่ให้การรักษาโดยcontinuous ultrasound 0.5 W/cm^2 มีค่า Median SNAP amplitude เพิ่มขึ้น และเมื่อเปรียบเทียบทั้ง 2 กลุ่ม พบว่ากลุ่มที่ได้รับ ultrasound มีค่า Median SNAP amplitude หลังการรักษา เพิ่มขึ้นแตกต่างจากกลุ่มที่ได้รับยา Diclofenac 75 mg/day อย่างมีนัยสำคัญ*

สรุป *: Ultrasound thermotherapy ให้ผลในการรักษาภาวะเส้นประสาทมีเดียนถูกกดรัดบริเวณ อุโมงค์ข้อมือในระยะรุนแรงน้อยถึงปานกลาง แต่การเปลี่ยนแปลงที่พบจากการตรวจไฟฟ้าวินิจฉัยควรจะมีการศึกษาเพิ่มเติม*