Effect of Different Ultrasonic Intensities in Reducing Carpal Tunnel Syndrome during Pregnancy

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ABSTRACT

This study was conducted to evaluate the effect of different intensities of pulsed ultrasonic on carpal tunnel syndrome (CTS) of normal pregnant ladies to determine the optimal intensity of pulsed ultrasonic which can used safely and effectively for reducing carpal tunnel syndrome during pregnancy. Forty-five pregnant women at the early third trimester complaining from idiopathic CTS (Pain, numbness and tingling of the hand), which confirmed by electrophysiological examination [reduced both sensory and motor median nerve conduction velocities] were participated in this study. They were selected from Obstetric Out patient Clinic at Kasr El-Ainy University Hospital. Their ages ranged from 25–35 years old, their BMI did not exceed 34Kg/m^2 and their gravidity ranged from 1-3 times. They were assigned randomly into three groups (A, B and C) equal in numbers according to the intensity of the applied ultrasonic as patients of group (A) treated by ultrasonic with intensity of (0.5 W/cm^2), and patients of group (B) treated by ultrasonic with intensity of (1.0W/cm^2) while patients of group (C) treated by ultrasonic with intensity of (1.5 W/cm^2) for 10 minutes, 3 times/week for 4 weeks accompanied by using a night wrist splint to keep her wrist in a neutral position during sleep. All patients in the three groups were assessed by median sensory conduction velocity SNCV and median motor conduction velocity MNCV, as well as present pain intensity (PPI) scale. The results of this study revealed a statistically significant increase in both sensory and motor nerve conduction velocities of patients in both groups (A and B) who treated by pulsed ultrasonic with intensity equal 0.5 W/cm^2 and 1 W/cm^2 but this increase was more pronounced in patients of group (A) who treated by pulsed ultrasonic with intensity of 0.5 W/cm^2. While group (C) who treated by pulsed ultrasonic with intensity equal 1.5 W/cm^2 showed a non significant increase in both SNCV and MNCV. The results also revealed a statistically significant decrease of the intensity of the experienced pain in all patients in the three groups (A, B and C). Thus it can be concluded that ultrasonic at low intensity (0.5 W/cm^2) is an effective physical method in treating CTS among normal pregnant ladies.

Key words: *Pregnancy, Carpal Tunnel Syndrome, Ultrasound, Nerve Conduction Velocity, Pain.*

INTRODUCTION

Carpal Tunnel Syndrome (CTS) is a compressive neuropathy of the median nerve at the wrist. Most cases of CTS are idiopathic, but sometimes it may be associated with different systemic conditions, including rheumatoid arthritis, diabetes mellitus, gout and pregnancy[1]. CTS is characterized by pain, parasthesias and weakness in muscles supplied by the median nerve. Symptoms are gradual in onset, but often worse at night and can awake the patient from sleep. As the condition worsens, daytime parasthesias become common and often are aggravated by daily activities like driving, holding object, washing, squeezing or even combing the hair[19].

Intrinsic risk factors of CTS are conditions that cause edema such as pregnancy, obesity and anatomic features that constrict the sides of the carpal tunnel. CTS is more likely to occur in persons with abnormally long lumbrical muscles or those

with anatomic variations of the hook of hamate[5].

CTS in pregnancy occurs generally between 30 and 40 years of age in both primiparous and multiparous women. The syndrome is usually most bothersome during the third trimester of pregnancy and/or during puerperium[33].

Different factors may interfere to worsen the case, such as the number of parity[10], the increase in body mass index (BMI) and sedentary life during pregnancy[17] as lack of physical activity help in reducing metabolic exchange and potentiating edema and thus, aggravating the case[28].

Alterations in fluid balance may predispose some pregnant women to develop CTS. So, fluid retention in the third trimester of pregnancy can lead to compression of the median nerve that passes under the retinaculum at wrist[37].

In addition, the cause of CTS during pregnancy could be related to relaxation of the ligamentous support of the wrist which occur secondary to the effect of the relaxin hormone or it might be due to postural changes during pregnancy that producing brachial plexus traction[6].

Nerve conduction tests are commonly used in the assessment of patients with CTS. A variety of median nerve motor and sensory tests have been introduced for the purpose of establishing the presence of median neuropathy in patients with CTS[34].

The diagnosis of CTS ought to be clinical, with nerve conduction tests used to provide objective evidence when necessary, and to support the diagnosis in less typical cases[14].

Median motor nerve conduction parameters are important for prognosis and localization of the lesion when a median sensory nerve action potential (SNAP) is unobtainable; however median motor nerve fiber dysfunction can be the only abnormality in acute CTS[16].

The median MNCV and mixed (motor /sensory) NCV in the forearm is frequently noted to be abnormally reduced with values commonly ranging from 40 m/sec to 50 m/sec in CTS compared to the normal value which is > 50 m/sec[36].

The reason for this remains unknown. It is hypothesized that because the fast conducting large diameter motor axons are more adversely affected than the small diameter fibers, the motor conduction velocity may reflect only the function of the smaller diameter fibers that conduct more slowly[24].

Ultrasonic (US) therapy is an intervention that is frequently used by physical therapist mainly to soft tissue injuries because of its presumed effect of accelerating the healing of damaged tissue. The use of ultrasonic may also assist in relief of signs and symptoms of inflammation[32,38].

Ultrasonic energy must be absorbed by the tissues to produce its physiological changes, especially in tissues rich in protein as well as hydrophilic tissues, such as muscles, joint capsules, tendons, and extracellular ligaments[4,20].

When Ultrasonic waves travel through tissues, a percentage of it, are absorbed and this leads to the generation of heat within this tissue[26]. The physiological responses attributed to the thermal effect include; increased collagen tissue extensibility, increased blood flow, change in nerve conduction velocity and increased pain threshold[21].

Ultrasonic treatment within the intensity range of 0.5-2.0 W/cm^2 may have the potential to induce various biophysical effects within tissue[2]. Experiments on the stimulation of nerve regeneration[31] and on nerve conduction by US treatment[9,21,35] and findings of an anti-

inflammatory effect of such treatment[13] support the concept that ultrasonic treatment might facilitate recovery from nerve compression[18].

This study was conducted to evaluate the effect of different intensities of repeated pulsed ultrasonic (0.5 W/cm^2, 1 W/cm^2 and 1.5 W/cm^2) on CTS in pregnant ladies, to determine the optimal intensity for reducing CTS during pregnancy.

SUBJECTS, MATERIAL AND METHODS

Subjects

This study was carried out on forty-five pregnant women at early of the third trimester from the Obstetric Out patient Clinic, Kasr El-Ainy University Hospital. They were complaining from idiopathic CTS (Pain, numbness and tingling of the hand), which confirmed by electrophysiological examination. Their ages were ranged from 25 – 35 yrs, their body mass index (BMI) did not exceed 34 Kgs/m^2 and their gravidity was ranged from 1-3 times.

Pregnant women with other predisposing causes for CTS and/or neuromuscular diseases that might affect median nerve transmission as diabetes mellitus, pre-eclampsia, rheumatoid arthritis, acute hand trauma, cervical spondylosis, previous surgeries in the forearm involving the median nerve and peripheral neuropathy were excluded from the study. Pregnant women having bilateral CTS affection were participated but for these cases, the dominant hand data only was enrolled in this study.

The forty five patients were assigned randomly into three groups equal in numbers (A, B and C) according to the intensity of the applied ultrasonic as follows:

Group A: received pulsed US at intensity of 0.5 W/cm^2.

Group B: received pulsed US at intensity of 1.0 W/cm^2.

Group C: received pulsed US at intensity of 1.5 W/cm^2.

All patients of the three groups (A, B and C) were treated by pulsed ultrasonic therapy for 10 minutes, three sessions per week for 4 weeks (total = 12 sessions) and used a night wrist splint to keep wrist in a straight position (neutral position) during sleep throughout the study duration (4 weeks). Physical characteristics of patients in the three groups are summarized in table (1).

Table (1): Statistical summary of the physical characteristics of patients in the three groups (A, B and C).

Variables	Groups	Range		Mean ± SD	Significance
		Min.	Max.		
Age (Yrs)	Group A	25	34	29.60 ± 2.97	P>0.05
	Group B	25	35	29.13 ± 2.70	
	Group C	26	34	28.93 ± 2.84	
Height (cms)	Group A	154	169	160.27 ± 5.78	P>0.05
	Group B	152	170	159 ± 5.68	
	Group C	150	168	159.4 ± 4.67	
Weight (Kgs)	Group A	71	91	77.27 ± 7.81	P>0.05
	Group B	70	91	76.33 ± 5.67	
	Group C	73	87	76.60 ± 5.53	
BMI (Kg/m^2)	Group A	28.48	33.02	30.01 ± 1.39	P>0.05
	Group B	28.35	33.31	30.19 ± 1.47	
	Group C	28.19	33.67	30.14 ± 1.69	

Material

Evaluative instruments

1- Present pain intensity (PPi) scale: a graphic rating scale with numerical values placed equidistantly along a line ranged from 0-4, was used to assess the intensity of the experienced pain for all patients in the three groups (A, B and C) before starting and after the treatment program.
2- Electromyographic (EMG) apparatus: (Neurorapid mod. Run Time EM 10/20 serial number 0196.0140 – 12w made in Italy), was used for the measurement of the median sensory nerve conduction velocity (SNCV) and motor nerve conduction velocity (MNCV) before and after the treatment program for all patients in the three groups (A, B and C).
3- Weight-Height scale: was used to measure the weight and the height of each patient before starting the study to calculate the BMI.

Treatment instruments

1- Therapeutic Ultrasonic apparatus: BTL-07P US therapy machine with microprocessor control, manufactured by BTL, Benesov. Czech Republic. A sound head transducer of 4 Cm^2 diameter and 1 MHz frequency is connected to the device. A button on the device was used to select the duty cycle of pulsed US for treatment. The duty cycle was pulsed mode 1: 4. It was used for the application of US treatment for patients in the three groups (A, B and C).
2- Neutral wrist splint: Synthetic neutral wrist splint was worn by each patient in the three groups, daily at night during sleep throughout the study duration (4 weeks).

Procedures

Evaluative Procedures

1- Present pain intensity (PPi) scale: Was used to evaluate the intensity of pain for all patients in the three groups (A, B & C) before starting and after the end of the treatment program.
2- Electrophysiological Evaluation: It was done for all patients in the three groups before participation in the study to confirm their diagnosis of CTS and after the end of the 12^{th} session of ultrasonic therapy to detect prognosis (if present).

During examination, the patient was seated on a wooden chair and her back was supported, the dominant forearm was rested on the examination table in supination position, with her elbow held slightly flexed.

A flexible bracelet ground electrode was placed around the wrist joint between the stimulating and recording electrodes at the level of the wrist creases and closer to the active recording electrode. This placement reduces the stimulus artefact.

The EMG apparatus was then adjusted as follows: time base at 5.0 ms/Div, the sensitivity at 4000.0 v/Div, the intensity was adjusted according to the site of stimulation; it was about 7mA at the wrist stimulation and 12mA for the elbow stimulation[11].

<u>Measurement of median sensory nerve conduction velocity (SNCV):</u>

- Active recording electrode was placed on the nerve trunk just above the wrist creases between the tendons of the flexor carpi radialis and palmaris longus muscles, the reference recording electrode was placed on the nerve trunk proximal to the active recording electrode by about 3-4 cms and the stimulating ring electrodes were placed on the index finger so, the negative pole was placed proximal to the recording electrode.

- The distance between the two points was measured by a tape measurement then, it was fed to the computer, which in turn calculates the median SNCV in m/sec.

Measurement of median motor nerve conduction velocity (MNCV):

- Active recording electrode was placed on the motor point of the abductor pollicis brevis muscle and the reference-recording electrode on the tip of the thumb. They were fixed to the patient's hand by adhesive plaster straps.
- The bipolar stimulating electrode was placed above the wrist joint between the tendons of palmaris longus and the flexor carpi radialis muscles on the course of the median nerve, with the negative pole distal toward the active recording electrode, and the positive pole proximal to stimulate the median nerve.
- Then the bipolar stimulating electrode was placed in the cubital fossa, just medial to the biceps tendon, with recording electrodes were applied at the same locations as in recording at wrist level.
- The distance between the two points of stimulation was measured by a tape measurement. Then, it was fed to the computer, which in turn calculates the MNCV in m/sec.

After the end of the assessment procedures, the electrodes (bipolar stimulating electrode, two surface ring electrodes, two surface recording electrodes and ground bracelet electrode) were removed and the skin was cleaned with alcohol.

Treatment Procedures

1. Ultra sonic treatment

Ten minutes of ultra sonic therapy over the carpal tunnel region as monotherapy at a frequency 1 MHz, pulsed mode 1:4 with a transducer of 4 cm^2. The machine was adjusted at the desired intensity (0.5, 1 or 1.5 W/cm^2 according to the treatment group). The ultrasound head was cleaned with alcohol to avoid any infection transmitted to the patient, then the adaptor plug inserted to the device. After cleaning the treatment area, adequate amount of sono-gel was placed on the ultrasound head and started a circular movement over the treatment area for 10 minutes.

2. Neutral Wrist Splint

A neutral wrist splint was worn for each patient in the three groups (A, B and C) daily at night throughout all duration of the study (4 weeks). This neutral wrist splint was used to keep the wrist in a straight position (neutral position) and to prevent the extreme wrist motion (flexion and extension) during sleep.

Data analysis and statistical design

The collected data were tabularized and computerized for analysis in the form of descriptive statistics using mean, standard deviation (SD) and percentage. Student t-test was used for comparing means between before and after treatment. Chi-square test was used for qualitative analysis. Also, one way analysis of variance (ANOVA) test was used for comparison between the three groups (A, B and C) after the treatment program.

RESULTS

The results of this clinical study were presented as follows:

a) Pain intensity measured by (PPi) score before and after treatment.
b) Sensory nerve conduction velocity (SNCV) before and after treatment.
c) Motor nerve conduction velocity (MNCV) before and after treatment.

Before starting the treatment program, in group (A) there were 7 patients complaining from moderate pain, 4 complaining from

severe pain and 4 complaining from unbearable pain. These complains were significantly (P<0.05) decreased after the end of the treatment as 8 patients reported no pain, 6 reported mild pain and only one patient reported the existence of moderate pain. In group (B) there were 7 patients complaining from moderate pain, 5 complaining from severe pain and 3 complaining from unbearable pain. These complains were significantly (P<0.05) decreased after the end of treatment as 8 patients reported no pain, 3 reported mild pain and 4 patients reported the existence of moderate pain. While in group (C) before the treatment there were 7 patients complaining from moderate pain, 4 complaining from severe pain and 4 complaining from unbearable pain. These complains were also significantly (P<0.05) decreased after the end of the treatment as 6 patients reported no pain, 2 reported mild pain but there were 7 patients still reported the existence of moderate pain as shown in table (2).

Table (2): Present pain intensity (PPi) scores of patients in the three groups (A,B and C) before and after the treatment program.

	Group A				Group B				Group C			
	Before treatment		After treatment		Before treatment		After treatment		Before treatment		After treatment	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
No pain	0	==	8	53.33	0	==	8	53.33	0	==	6	40
Mild pain	0	==	6	40	0	==	3	20	0	==	2	13.33
Moderate pain	7	46.66	1	6.67	7	46.67	4	26.67	7	46.67	7	46.67
Severe pain	4	26.67	0	==	5	33.33	0	==	4	26.67	0	==
Unbearable pain	4	26.67	0	==	3	20	0	==	4	26.67	0	==
X^2	12.48				11.83				14.00			
P-value	P<0.05				P<0.05				P<0.05			

As a response to treatment program, the Sensory nerve conduction velocity (SNCV) in patients of group (A) showed a highly significant (P<0.001) increase as it increased from 45.18 m/sec to 55.16 m/sec with a percentage of improvement equal 22.09%. In patients of group (B), the SNCV also showed a highly significant (P<0.005) increase with a percentage of improvement equal 20.06%. While SNCV in patients of group (C) showed a non significant (P<0.92) increase with a percentage of improvement equal only 15.73% as shown in table (3) and Fig. (1).

Table (3): Mean and SD of SNCV for patients in the three groups (A, B and C) before and after the treatment program.

	SNCV (m/sec)					
	Group A		Group B		Group C	
	Before treatment	After treatment	Before treatment	After treatment	After treatment	After treatment
Mean	45.18	55.16	45.19	53.65	45.17	52.09
SD	± 1.97	± 1.6	± 2.16	±1.9	± 2.04	± 1.62
MD	9.98		8.46		6.92	
Percentage of improvement	22.09%		18.72%		15.73%	
t-value	23.05		20.06		11.6	
Level of significance	P<0.001		P<0.005		P<0.92	

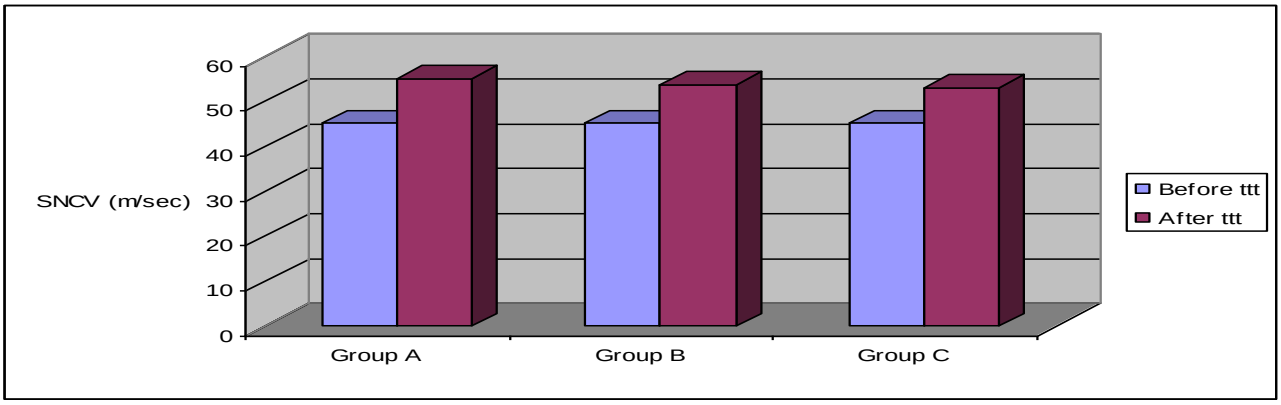

Fig. (1): Mean values of SNCV for patients in the three groups (A, B and C) before and after the treatment program.

The motor nerve conduction velocity (MNCV) in patients of group (A) showed a highly significant (P<0.001) increase as it increased from 45.13 m/sec to 53.93 m/sec with a percentage of improvement equal 19.5%. In patients of group (B), the MNCV showed a significant (P<0.05) increase with a percentage of improvement equal 17.34%. While MNCV in patients of group (C) showed a non significant (P<0.89) change with a percentage of improvement equal only 15.2% as shown in table (4) and Fig. (2).

Table (4): Mean and SD of MNCV for patients in the three groups (A, B and C) before and after the treatment program.

	MNCV (m/sec)					
	Group A		Group B		Group C	
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Mean	45.13	53.93	45.15	52.98	45.12	51.99
SD	±1.71	± 1.73	± 2.32	±2.06	± 1.97	± 1.89
MD	8.8		7.83		6.86	
Percentage of improvement	19.5%		17.34%		15.2%	
t-value	23.96		17..27		9.95	
Level of significance	P<0.001		P<0.05		P<0.89	

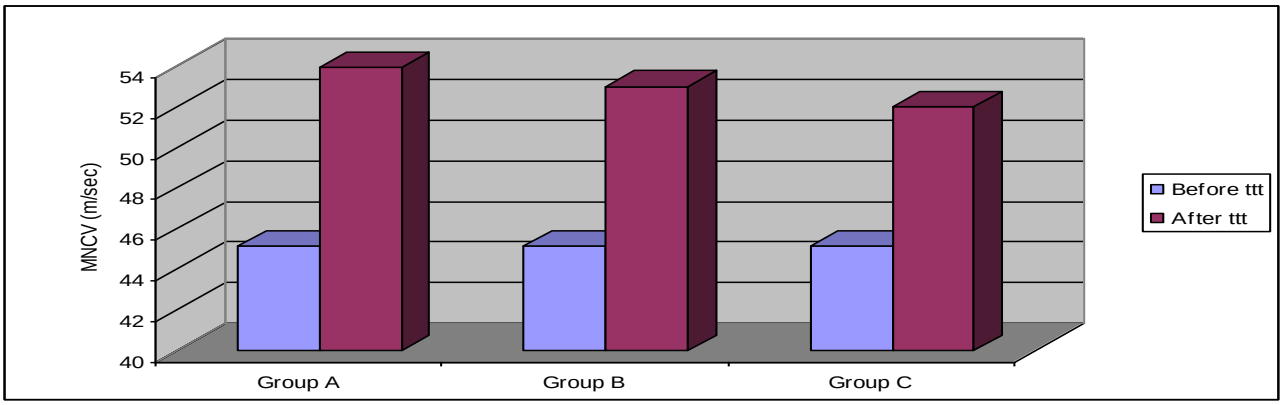

Fig. (2): Mean values of MNCV for patients in the three groups (A, B and C)before and after the treatment program.

DISCUSSION

This study was conducted to evaluate the effect of different intensities of repeated pulsed ultrasonic (0.5 W/cm^2, 1 W/cm^2 and 1.5 W/cm^2) on CTS in normal pregnant women by evaluating the median nerve sensory (SNCV) and motor (MNCV) conduction velocity as well as the intensity of pain.

The results of this study revealed a statistically significant increase of both sensory and motor nerve conduction velocities in patients of both groups (A and B) who treated by pulsed ultrasonic with intensity equal to 0.5 W/cm^2 and 1 W/cm^2 but this increase was more pronounced in patients of group (A) who treated by pulsed ultrasonic with intensity equal to 0.5 W/cm^2. While patients of group (C) who treated by pulsed ultrasonic with intensity equal 1.5 W/cm^2 showed a non significant increase in both SNCV and MNCV. The results are also revealed a statistically significant decrease in the intensity of pain measured by the present pain intensity (PPI) scale in all patients in the three groups (A, B and C).

The results of this study are in agreement with Cosentino et al. (1983)[7] who compared SNCV in the median nerve after 10 minutes of US treatment with SNCV in the median nerve after 10 minutes of placebo US treatment and they found a significant improvement of SNCV after treatment intervention by US.

These results are also, agree with Piravej and Boonhong (2004)[30] who mentioned that low intensity US (0.5 W/cm^2) was an effective therapeutic modality for treating mild to moderate CTS. This also confirmed by Raso et al. (2005)[31] who concluded that low intensity therapeutic pulsed US (0.5 W/cm^2) enhances nerve regeneration.

These results also, agree with an experimental study by Hong et al. (1988)[18] who found that lower doses of US (0.5 W/cm^2 or 1.0 W/cm^2) could facilitate recovery of compression neuropathy. But, higher doses could induce an adverse effect. They suggested that increased local blood flow induced by lower-dose US treatment may contribute to nerve regeneration or recovery of nerve conduction in entrapment neuropathy.

These results could be explained by Michlovitz (2005)[27], who mentioned that, the use of low-dosage of pulsed US on the median nerve in CTS patients restored the normal connective tissue extensibility, which in turn decreased the nerve entrapment in its surrounding connective tissues. Thus, significantly increased MNCV.

Also, Lazar et al. (2001)[23] mentioned that, US therapy act on various aspects of the natural healing process of the nerve including cellular and molecular processes which involved in promoting Wallerian Degeneration as well as the rate and specificity of axonal regeneration and re-myelination.

Many reasons have been proposed to explain the improvement in MNCV and SNCV as well as, decreased the intensity of pain: The first is the mechanical effects of US on the nervous system which may result in alteration of the pressure in the nervous system and subsequently to a dispersion of any existing intra-neural edema. This may normalize the pressure gradient in the carpal tunnel and consequently normalize the blood supply and the axonal transport system which can help in reducing edema, pain as well as causing axonal regeneration of the median nerve fibers which will evidenced by significant increase in MNCV[39]. The second is the heating property of US. The physiological responses attributed to a thermal mechanism include; increased collagen tissue extensibility as well as, blood flow, change in NCV, change in the rate of nerve regeneration, tissue metabolism,

permeability of biologic membranes as well as, increased pain threshold[12,29].

Mardiman et al. (1995)[25] explained the increase of pain threshold after US application by the absorption of US by the nociceptive fibers (A-delta and C) which block the pain transmission. Also, Mc Diarmid et al. (1996)[26] stated that following US application, pain threshold is usually increased due to the heat produced by US which could result in counter irritation heat activation for large diameter nerve fibers or an altering in the response for stimulation of the pain receptors (free nerve ending).

Young (1999 & 2002)[40,41] reported that the analgesic effect of US is secondary and is related to interference with the chemical mechanism of pain. As US induced reduction in the sodium-potassium ATPase pump activity, if a decrease in the pump activity occurs in plasma membranes it may inhibit the transduction of noxious stimuli and subsequent neural transmission which may account in part for the pain relief.

Results of the present study may also, be affected by wearing a special night wrist splint that keeps the wrist in a neutral position. Splinting is a noninvasive method for helping to decrease the uncomfortable symptoms of CTS during pregnancy[8] because the pressure in the carpal tunnel is lowest in neutral wrist position, with the pressure rising significantly as the wrist is moved into flexion or extension[15]. Also splinting the wrist at a neutral angle helps to decrease repetitive flexion and extension, thereby relieving mild soft tissue swelling or tenosynovitis[22]. These results are in agreement with Baysal et al. (2006)[3] who suggest that a combination of splinting, exercise and US therapy is a preferable and an efficacious conservative type of treatment in CTS.

Thus, it could be concluded that pulsed ultrasonic with low intensity (0.5 W/cm^2) for 10 minutes, three times /week accompanied by the use of neutral night wrist splint are seem to be an optimal therapeutic modality which can be used safely to reduce the symptoms of CTS during pregnancy.

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الملخص العربي

تأثير الجرعات العلاجية مختلفة الشدة للموجات فوق الصوتية على تخفيف أعراض الضغط على عصب الرسغ الأوسط لدى السيدات الحوامل

تهدف هذه الرسالة إلى دراسة تأثير الجرعات العلاجية مختلفة الشدة للموجات فوق الصوتية على تخفيف أعراض الضغط على عصب الرسغ الأوسط لدى السيدات الحوامل. و قد أجريت هذه الدراسة على خمسة وأربعين سيدة حامل ممن تتواوح أعمارهن بين 25-35 سنة و يعانين من الضغط على عصب الرسغ الأوسط تم اختيارهن من عيادة متابعة الحمل بمستشفى قصر العيني الجامعي . وقد تم تقسيمهن إلى ثلاث مجموعات متساوية في العدد (أ، ب، ج). و تم علاج المريضات في الثلاث مجموعات بالموجات فوق صوتية المتقطعة بشدة 0.5 وات/سم^2 للمجموعة (أ)، 1.0 وات/سم ^{2} للمجموعة (ب)، 1.5 وات/سم^2 للمجموعة (ج) وذلك لمدة عشر دقائق بواقع ثلاث مرات أسبوعياً لمدة شهر (إجماليا 12 جلسة) بالإضافة إلى ارتداء ساند للرسغ في أثناء النوم يوميا وتم تقييم جميع الحالات عن طريق قياس شدة الألم وكذلك سرعة توصيل العصب الأوسط (الحسية والحركية) قبل وبعد البرنامج العلاجي . وقد أظهرت النتائج وجود نقص دو دلالة إحصائية في مقياس شدة الألم كنتيجة للبرنامج العلاجي في المجموعات الثلاث . مع وجود زيادة ذات دلالة إحصائية في سرعة توصيل العصب الأوسط (الحسية والحركية) في المجموعتان (أ ، ب) و عدم وجود فروق ذات دلالة إحصائية في مستوى التحسن للمجموعة (ج) فيما قبل و بعد البرنامج العلاجي. وقد وجد أن أعلى نسبة للتحسن كانت في المجموعة الأولي (0.5 وات/سم^2) وأن اقل نسبة للتحسن كانت في المجموعة الثالثة (1.5 وات/سم^2). لذلك توصى الدراسة باستخدام الموجات فوق الصوتية المنخفضة الشدة (0.5 وات/سم^2) لتقليل الضغط على عصب الرسغ الأوسط لدى السيدات الحوامل .

الكلمات الدالة : الحمل- الضغط على عصب الرسغ الأوسط - الموجات فوق الصوتية العلاجية - سرعة توصيل العصب – مقياس شدة الألم .