Effect of Low Intensity Laser Irradiation on Antidromic Conduction Latencies and Pain Perception in Pregnant Patients with Carpal Tunnel Syndrome

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ABSTRACT

This study was conducted to determine the effect of low intensity laser irradiation on antidromic conduction latencies and pain perception in pregnant patients (multiparous 1 to 3 times) with carpal tunnel syndrome (CTS). Forty patients were included in the study, and were divided into two equal groups in number, study and placebo, under randomized condition. Their age ranged from 28 to 34 years. In the study group, irradiation was applied to ten points on the dominant forearm along the course of the median nerve from elbow to second digit. For the placebo condition Sham irradiation was delivered by applying the laser unit without activating the probe. Antidromic nerve conduction latencies were recorded at pre irradiation as baseline and throughout 45 min. with 5 min. intervals. Pain perception and nerve conduction velocity were measured pre and 45 min. post irradiation. Data analysis revealed that low intensity laser irradiation, at the parameters used here, produced a direct, localized significant increase in conduction latencies corresponding to a decrease in conduction velocity in the median nerve and correlates with reduction of pain in pregnant patients with CTS over a period of 45 min. post irradiation.

Key Words: *Low intensity laser irradiation, nerve conduction, pain, pregnancy and carpal tunnel syndrome*

INTRODUCTION

Carpal tunnel syndrome (CTS) is a clinical diagnosis of median nerve compression based on patients history and physical examination[22]. It is an extremely common and disabling repetitive stress injury that involves pain, inflammation and altered neurological function in the relatively superficial distal median nerve[4]. It is not always accompanied by abnormalities in conventional nerve conduction studies[13].

The triad of numbness, tingling and pain of the hands (CTS) often occurs during pregnancy and sufficiently serve as to disturb sleep[14,15,20] Increased median nerve latencies occurred as early as the third month of pregnancy and as late as 20 months postpartum[14]. The time of maximally delayed conduction in the distal median nerve ranged from the sixth month of pregnancy to the third postpartum month[20]. Nerve conduction studies

are sensitive indices of the presence, course and evaluation of the CTS associated with pregnancy[20].

Estimates in the literature of frequency of severe symptoms in the hands during pregnancy range from 1.2 to 16 percent of all pregnant women [15]. The dominant hand is reported to be affected initially and to a greater extent[13,14,20]. Increased symptoms have been noted with subsequent pregnancies and in those who have an excessive weight gain [20]. Ekman-Ordeberg et al.,[15] have reported increased incidence of CTS in women using oral contraceptives and suggested the etiology of this syndrome, that hormone relaxin might be the agent which is responsible for the fluid retention in the perineural connective tissue leading to presence of edema accompanied with CTS[15].

Clifford[13] postulated that it might be related to relaxation of the ligaments of the wrist secondary to the action of relaxin[14] or it might be due to postural changes of pregnancy producing brachial plexus traction [20].

Conventional treatment involves rest, splinting, work modification, anti-inflammatory medication, corticosteroid injection, and at times, surgery[4,15]. As might be expected from this variety of approaches, response is often inadequate. The use of laser at relatively low power output, has recently been promoted as an effective therapy for the treatment of a variety of conditions, including promotion of wound healing, reduction of oedema and relief of pain at various aetiologies[11] including CTS[4]. In spite of the wide clinical usage, the therapeutic application of these devices attracted considerable skepticism from some sources for the relief of pain [22,4,17]. The reasons for this are various, but include the generally poor quality of many of the published papers in this area, the continued preponderance of foreign language publications, couplied with the lack of any obvious mechanism (s) of therapeutic action[2,3,19].

Parallel studies have been employed to determine the effects of low intensity laser radiation upon peripheral neurophysiology. These nerve conduction studies demonstrated laser-mediated effects that are critically dependent upon irradiation parameter[6,25] and greatest increases in conduction latency occur at a radiant exposure of 1.5 J/cm^2 by Gallium Aluminium Arsenide (Ga Al As), 830 nm continuous wave which correlated to decrease in conduction velocity. However, reports to date have been contradictory. Greathouse et al.,[16] investigated the effect of Gallium Arsenide (Ga As), 904 nm pulsed at 73 Hz upon conduction in human superficial radial nerve and found no significant effect upon recorded latencies. In contrast, Snyder-Mackler and Bork [23] found significant increase in latency in the same nerve using ImW Helium-Neon (He-Ne) laser continuous wave (632.8 nm: 19 mJ/cm^2). Baxter et al., [11] using a more therapeutical relevant laser dose (830 nm, 9.6 J/cm^2) has demonstrated a significant laser mediated effect upon antidromic latencies in human median nerve in vivo.

According to subsequent studies, the incidence of CTS during pregnancy has been in the range from 1 to 50% and can result in permanent disability if left untreated. There is a gap in the literature upon the neurophysiological effects of laser on pathological condition especially pregnant with CTS. Laser has been claimed to be useful in ante natal management[21]. Thus, parallel to these studies, the current study was conducted to determine the effect of low intensity laser irradiation on antidromic conduction latencies and pain perception in pregnant patients with CTS.

SUBECTS, MATERIALS AND PROCEDURES

Subjects

Subjects for this study were recruited from Obstetrics Clinic of Kaser El-Aini Hospital. During attendance, all subjects (n = 40) received a briefing on the procedures and purpose of the experiment. All subjects were pregnant in six months with carpal tunnel syndrome (CTS) according to medical diagnosis. Their age ranged from 28 to 34 years (multiparous from 1 to 3 times). They were assigned randomly into two groups of equal numbers, study and placebo. Patients were considered to have a significant compression of the median nerve at the wrist if the distal motor latency was greater than 5.0 msec., or the distal sensory latency was greater than 3.5 msec, or both and also have positive phalen s sign.

Materials

1- Ga Al As 830nm. continuous wave laser diode was used for irradiation.
2- Electromyography (EMG) apparatus with
   - standard bipolar muscle stimulator.
   - Hydrogel electrodes.
   - Digital ring electrode.
3- Simple mercury thermometer for monitoring the ambient temperature.
4- Verbal numerical scale (VNS) was used for assessment of pain intensity.

Procedures

Evaluative Procedures:

- Recording procedure includes a standard bipolar muscle stimulator to identify and mark the course of the median nerve between the elbow and the second digit. For the purpose of antidromic stimulation and recording, hydrogel electrodes were positioned 3cm apart on the second digit. An earth electrodes was fastened approximately 8 to 10 cm above the wrist. Supramaximal stimuli 100 μ_s pulse were delivered at a frequency of 1 Hz. Recording was performed every two min. until the evoked response was found to be stabilized. Once stabilized, an initial recording was taken to establish a baseline for each subject and nerve conduction was measured at 5 min. intervals throughout 45 min. (the duration of the experiment). Nerve conduction records were taken at onset, negative and positive peak latencies (ms), peak to peak duration (ms) and peak to peak amplitude (μv). Initial measurement and subsequent values expressed as a difference from these were used as a basis for statistical analysis.
- VNS was used for assessment of pain, the patient was allowed to choose a number between 1 to 10 which represent her pain intensity. Pain perception was measured pre irradiation and at 45 min. post irradiation.
- Nerve conduction velocity was recorded also pre irradiation and at 45 min. post irradiation.

Irradiation Procedures

- The position of the patients were supine, with the dominant arm exposed and rested comfortably for at least 10 min. The whole volar surface of the forearm was prepared with alcohol to remove reflecting lipids on the surface. Also, the stimulation and recording site at the elbow and second digit were further cleaned with alcohol to improve electrical conductance.
- The ambient temperature was maintained at 23°C. A shift of $\pm$0.5°C was used as a

maximum limit for temperature variation during a single experiment.

- The area of skin chosen for application of infrared laser radiation corresponded to the course of the median nerve between the elbow and the second digit were determined by the nerve conduction technique.
- In the study group (n = 20), all points were irradiated with the treatment probe in contact with the skin using a continuous wave 830 nm Ga Al As laser diode. At each point, the 40 mW laser diode was used for a 30 second, delivering a total of 1.5J of laser radiation per point which corresponding to a radiant exposure of 9.0 J/cm^2 directly under the laser treatment head (calculated theoretically). This energy density was selected as being within the commonly accepted therapeutic range[10]
- Laser irradiation was applied at ten points along the course of the median nerve. Four equidistant points in the palm of the hand, two just proximal and distal to the flexor reticulum at the wrist and finally four equidistant points on the forearm.
- For placebo group (n = 20), sham irradiation was delivered by applying the laser unit without activating the probe following the same procedures.

Data Analysis

The statistical analysis of the data were conducted by using analysis of variance (ANOVA), while comparing the values pre and post irradiation t-paired test was used. Post hoc analysis was used to evaluate significant differences between means ($P<0.05$).

RESULTS

Nerve Conduction

Table (1) and Fig. (1) Showed the results of negative peak latency differences scores and conduction velocity for both study and placebo groups pre and post 45 min. irradiation. Statistical analysis showed significant increase in conduction latency and decrease in conduction velocity in the study group when compared to placebo group ($P<0.05$).

Table (1): Negative peak latency differences and conduction velocity pre and 45 min. post irradiation for both groups (P < 0.05)

Variable	Time of assessment	Study group (means ± SD)	Placebo group (means ± SD)
Negative peak Latency differences	Pre irradiation 45 min. post irradiation	6.89 ± 0.12 ms 7.40 ± 0.15 ms	6.96 ± 0.13 ms 6.96 ± 0.13 ms
Conduction Velocity	Pre irradiation 45 min. post irradiation	61.14±3.89 ms 58.48±4.76 ms	56.12 ± 2.96 56.12 ± 2.96

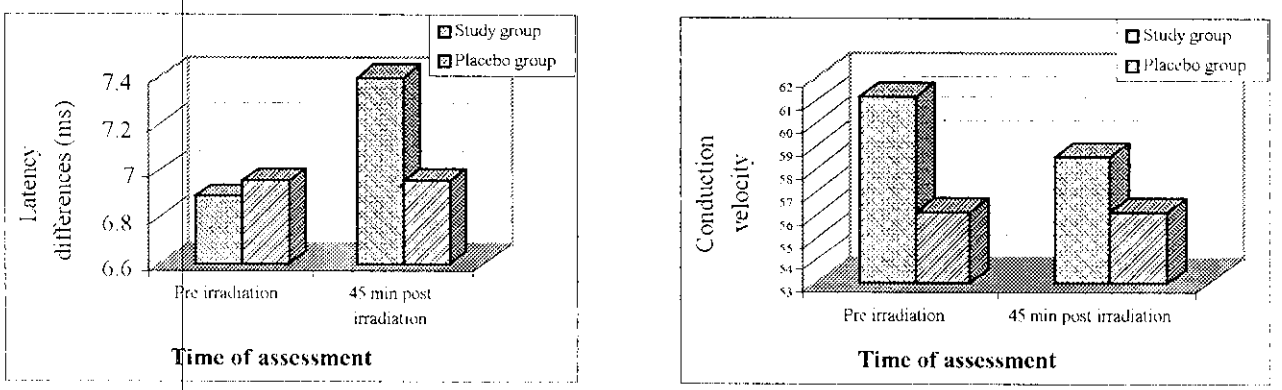

Fig. (1) Negative peak latency differences and conduction velocity pre and 45 min. post irradiation for both groups

Data analysis revealed progressive increase in the negative peak latency difference scores in the study group whilst in the placebo group, remained relatively stable over the course of the experiment. Peak to peak amplitude showed no significant difference as an effect of time between both groups.

Pain Perception

Table (2) and Fig (2) showed mean ± standard deviation of mean of the pain value in the placebo and study groups. Data analysis indicate a significant reduction of pain in study group ($P<0.05$) compared to placebo group ($P>0.05$). These results were consistent with increased in the negative peak latency differences scores and decreased in conduction velocity. So, the results revealed that laser irradiation applied to intact skin at the parameters used in this study, may produce a direct, localized effect upon conduction in the median nerve which correlate with reduction of pain in pregnant patients with CTS over a period of 45 min. post irradiation.

Table (2): Pain assessment in the study and placebo groups including pre and post t test (mean ± SD)

Pain intensity	Study group	Placebo group
VNS (pre irradiation)	7.126 ± 1.318	6.265 ± 1.312
VNS (45 min. post irradiation)	3.612 ± .743	5.895 ± 1.842
P value	< 0.05*	> 0.05

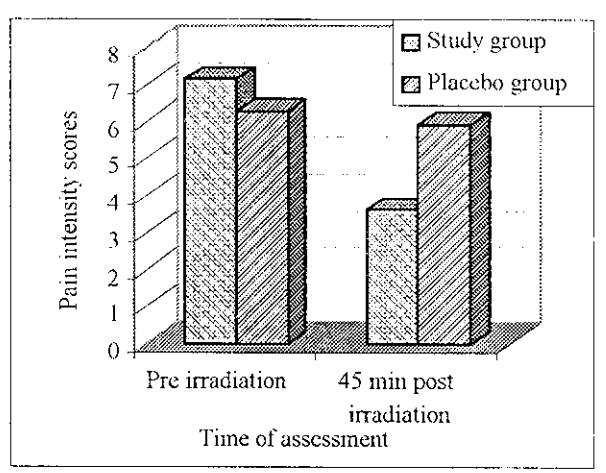

Fig. (2) Pain assessment pre and post irradiation for both groups.

DISCUSSION

The putative analgesic effects of low intensity laser irradiation remain controversial, mainly due to the poor quality of some of the publications within this field and lack of an obvious mechanism of action[2,3,4]. Clinical and animal studies provides significant information about the interaction of laser irradiation with nerve tissue. Physiological studies often[1,6,15,16,18] but not always[5,8] show that laser irradiation can alter nerve conduction, and evoked potentials. In the light of this, and parallel to the previous studies upon neurophysiological effects of laser and due to lack of such studies upon healthy pregnant or pregnant patients with CTS, the current study was conducted to determine the effects of low intensity (9.0 J/cm^2) laser (GA Al As 830 nm laser diode continuous wave) irradiation on antidromic conduction latencies and pain perception in pregnant patients with CTS.

The results of this study demonstrated the potential of low intensity infrared laser irradiation (at the parameter used here) applied to the skin over the course of a peripheral median nerve to significantly affect conduction latencies, conduction velocity in that nerve and pain perception. Thus, the finding of increased antidromic conduction latencies which correspond to decrease conduction velocity support earlier observations of such laser mediated effects in the human superficial nerve[23] and in the median nerve[6,10,12]. In contrast to Baxter et al.,[12] and Snyder-Mackler and Bork[23] the current study assessed the effects over a period of 45 min. post irradiation and has established that the effect mediated by laser is relatively long lasting, (>45min.) which is consistent with Baxter et al.,[10,12] (>55 min.) and well localized to the area of irradiation[9,10]. Also, Walsh et al, [25] have consistently demonstrated laser mediated effects on nerve conduction that are critically dependent upon irradiation parameters and in particular, that the greatest increases in conduction latencies corresponding to decrease in conduction velocity occur at a radiant exposure of 1.5 J/cm^2[15].

The current study assessed the effects of low intensity laser irradiation over a period of 45 min. post irradiation on pain perception and has revealed a significant reduction of pain and correlated with significant increase in conduction latencies and decrease conduction velocity and was shown to be long lasting in study group compared to placebo group. In contrast, Lowe et al.,[19] failed to demonstrate any hypoalgesic effect of low intensity laser irradiation (830nm) at a radiant exposure 1.5J/cm^2 on experimental ischemic pain and attributed this effect to the ischemic pain induction technique. Previous studies have used different types of laser with incomplete specification of irradiation parameters, also lack of nerve conduction studies with pain assessment upon pregnant patients with CTS or healthy pregnant limits quantifiable comparison with other studies.

There is well-established relationship between temperature and conduction velocity, low temperature produced prolonged latencies and slower conduction velocity, while the higher temperature produced faster latencies and faster conduction velocity.

Low intensity laser irradiation at the radiant exposure used in this study is athermal [13] and measurement of skin temperature performed close to the laser applicator was found no more than 0.5°C rise in temperature so, the observed effects is not thermally mediated. Such temperature increases are not in keeping with the direction of the observed shifts in antidromic conduction latencies, which would be expected from a decrease in

skin temperature. In agreement with this explanation Lowe et al.,[19] investigated the effect of low intensity laser (830nm; 1.5 12J/cm^2) on peripheral neurophysiology and skin temperature in human median nerve and found significant decrease in skin temperature following a lowest radiant exposure (1.5J/cm^2) coupled with significant increase in conduction latencies. While no such changes were found in the other group, the authors found that observed changes (increases and decreases) in latencies were inversely related to change in skin temperature and may be with increasing radiant exposure, localized heating associated with photothermal mechanisms can overcomes any photobiological effects upon microvasculature.

Also, the observed effects in the current study may be assumed to cooling of the subjects exposed limb, but this is clearly not the case as ambient temperature remained stable as well as this effects not seen in the placebo group.

CONCLUSION

In conclusion, the results of this study demonstrated a measurable and significant increase in antidromic conduction latencies corresponding to a decrease in conduction velocity in the median nerve in pregnant patients with CTS over a period of 45 min. post irradiation with low intensity laser at the parameter used in this study. These changes in nerve conduction was correlated with significant reduction of pain and the effects shown to be long lasting 45 min. Further controlled studies are recommended to establish the neurophysiological and hypoalgesic effects of this modality with the same parameters and subjects used here for more than 45 min. to document its long lasting effect.

REFERENCES

1. Anders, J. J., Borke, R. C., Woolrry, S. K. and Van DeMerwe, W. P.: Low power irradiation alters the rate of regeneration of the rat facial nerve . Lasers in Surgery and Medicine, 13: 72-82, 1993.
2. Basford, J. R.: Low energy laser treatment of pain and wound: hype, hope or hokum? Mayo Clinic Proceedings, 61: 671-675, 1986.
3. Basfard, J. R.: Low energy Laser therapy: Controversies and new research findings . Lasers in Surgery and Medicine, 9: 1-5, 1989.
4. Basford, J. R.: Low intensity laser therapy; still not an established clinical tool . Lasers in Surgery and Medicine, 16: 331- 342, 1995.
5. Basford, J. R., Daube, J.R., Hallman, H.O., Millard, T.L., and Moyer, S.K.: Does low intensity helium-neon laser irradiation alter sensory nerve action potenlials or distal latencies? , Lasers in Surgery and Medicine, 10:35-39, 1990.
6. Baxter, G. D., Allen, J. M., and Bell, A. J.: The effect of low energy density laser irradiation upon human median nerve conduction latencies , J. Physiol., 435: 63p. 1991.
7. Baxter, G. D., Allen, J. M., Bell, A. J., and Diamanthopoulosc, C.: Effect of laser (830 nm) upon conduction in the median nerve. American Society for laser Medicine and Surgery , (Abstract), Lasers in Surgery and Med. Suppl., 3: 79, 1991.
8. Baxter, G. D., Allen, J.M., Bell, A. J., and Ravey, J.: The effect of infrared laser irradiation upon contralateral nerve conduction latencies in the human median nerve , Irish Journal of Medical Science, 160: 364, 1991.
9. Baxter, G. D., Allen, J. M., Walsh, D. M., Bell A. J., and Ravey, J.: Localization of the effect of low energy laser irradiation upon conduction latencies in the human median nerve in vivo , J Physiol, 446: 445 P, 1992.
10. Baxter G. D., Bell, A. J., Allen, J. M., and Ravey, J.: Laser mediated increase in median nerve conduction latenci Ir J Med Sci, 160: 145-146, 1991a.

11. Baxter, G.D., Bell, A. J., Allen, J.M. and Ravey, J.: Low level laser therapy: Current clinical practice in Northern Ireland , Physiotherapy, 77, 171-178, 1991b.
12. Baxter, G.D., Walsh, D.M., Allen, J.M., Lowe, A.S., and Bell, A.J.: Effects of low intensity infrared laser irradiation upon conduction in the human median nerve in vivo , Experimental Physiol., 79: 227-234, 1994.
13. Clifford, J.C.: Provocative exercise maneuver: its effect on nerve conduction studies in patients with carpal tunnel syndrome , Arch. Phys. Med. Rehabil., 75: 8-10, 1994.
14. Crisp, W.E., and De Francesco, S.: The hand syndrome of pregnancy , Obstet. Gynecol, 23: 433-437, 1964.
15. Ekman-Ordeberg, G., Salgeback, S., and Ordeberg, G.: Carpal tunnel syndrome in pregnancy , A prospective study, 66: 11-14, 1987.
16. Greathouse, D. G., Currier, D. P., and Gilmore, R.L.: Effects of clinical infrared laser on superfacial radial nerve conduction , Physical therapy, 65: 1184-1187, 1985.
17. Hansen, H. J., and Thorse, U.: Low power laser biostimulation of chronic ora-facial pain: A double-blind placebo controlled cross-over study in 40 patients , Pain, 43:169-180, 1990.
18. Lowe, A. S., Baxter, D. G., Walsh D.M. and Allen, J.M.: Effect of low intensity laser (830 nm) irradiation on skin temperature and antidromic conduction latencies: Relevance of radiant exposure , Lasers in Surgery and Medicine, 14: 40-46, 1994.
19. Lowe, A.S., McDowell, B., Walsh, D.M., Baxter, G.D. and Allen, J.M.: Failure to demonstrate any hypoalgesic effect of low intensity laser irradiation (830nm) of erb s point upon experimental ischemic pain in humans , Lasers in Surgery and Medicine, 20: 69-76, 1997.
20. Melvin, J., Burnett, C. and Johnson, E.: Median nerve conduction in pregnancy , Arch. Phys. Med Rehabil, Feb, 75-80, 1969.
21. Sapsford, R., Daxton, J. and Markwells: Women s health, A textbook for physiotherapists: Electrotherapy options for the prenatal period and beyond, 1st Ed. P. 293, 1988.
22. Schuind, F. and Pasteel, J.L.: Idiopathic Carpal tunnel syndrome: histologic study of flexor tendon synovium , J. Hand Surgery, 15 A: 497-503 1990.
23. Snyder-Mackler, L. and Bork, C.E.: Effect of helium-neon laser irradiation on peripheral sensory nerve latency , Phys. Ther, 68:223-225,1988.
24. Todnem, K., Knudsen, G., Rise, T., Nyland, H. and Aril, J.: The non linear relationship between nerve conduction velocity and skin temperature , J. Neurol. Neurosurgery and Psych., 52: 179-191, 1989.
25. Walsh, D. M., Baxter, G. D., and Allen, J. M.: The effect of 830 nm irradiation upon conduction in the frog (Rana Temporaria) sciatic nerve in vitro , Laser Therapy, 7: 1,5-10, 1995.

الملخص العربي

تأثير العلاج باستخدام أشعة الليزر المنخفض الشدة على زمن التوصيل المعاكس وكذا درجة الإحساس بالألم في حالات الضغط على عصب الرسغ الأوسط للحوامل

يهدف هذا البحث إلى تحديد تأثير أشعة الليزر المنخفض الشدة على زمن التوصيل المعاكس ودرجة الإحساس بالألم في حالات الضغط على عصب الرسغ الأوسط للحوامل . وقد شملت الدراسة أربعون مريضة تراوحت أعمارهم بين ٢٨ و ٣٤ عاما وقد تم تقسيمهم عشوائيا إلى مجموعتين متساويتين في العدد . تم استخدام أشعة الليزر المنخفض الشدة للمجموعة الأولى على ١٠ نقاط على مسار عصب الرسغ الأوسط ما بين مفصل الكوع وحتى الاصبع الثاني لمدة ٤٥ دقيقة بفارق خمس دقائق أما المجموعة الثانية فاعتبرت ضابطة وتم استخدام نفس الطريقة مع عدم تشغيل جهاز الليزر وأثبتت النتائج فروقا ذات دلالة إحصائية بين المجموعتين الأولى والضابطة وكذلك في القياسات ما قبل وبعد اجراء التجربة في المجموعة الأولى مما يثبت كفاءة استخدام أشعة الليزر المنخفض الشدة إذ حدثت زيادة مباشرة ومحددة في زمن التوصيل العاكس وانخفاض في سرعة التوصيل للعصب الأوسط وكانت النتائج متزامنة مع انخفاض درجة الإحساس بالألم لمدة ٤٥ دقيقة (زمن الدراسة) .