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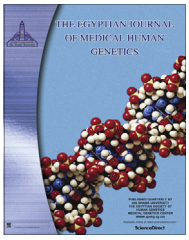

ORIGINAL ARTICLE

The response of skin hardness and pain sensation to ultrasonic treatment in lipodermatosclerosis patients

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KEYWORDS

Lipodermatosclerosis;
Pain;
Skin hardness;
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Abstract *Background:* Lipodermatosclerosis (LDS) is considered a type of panniculitis (inflammation of subcutaneous fat). Patient experiences severe pain, increased stress, swelling, walking problems and decreased quality of life. The end result of untreated LDS is ulcer formation with high incidence of delayed healing and infection. In addition to psychological problem, the financial costs can be significant.

Aim of the study: To evaluate the efficacy of ultrasonic waves (U.S.) in the treatment of lipodermatosclerosis.

Methods: Forty patients with lipodermatosclerosis from both sexes aged from 42 to 65 years were assigned into two groups of equal number. The study group (group A) received continuous U.S. three times/week at frequency of 3 MHz in addition to routine treatment which consisted of wearing grade 2 compression stocking (30–40 mmHg) during weight bearing conditions, patients were advised to try to decrease weight bearing as much as possible during the treatment period and circulatory exercise for 15 min at least 5 times/day, control group (group B) received placebo U.S. plus routine treatment. Pain sensation and skin hardness were assessed in both groups using numeric rating scale (NRS) and durometer.

Results: The results revealed a significant decrease in mean values of pain sensation and skin hardness in the study group compared to the control group after treatment.

To conclude that therapeutic ultrasound was effective in controlling of lipodermatosclerosis disease as regards, decreasing pain sensation and skin hardness.

1. Introduction

Lipodermatosclerosis (LDS) is characterized by lower leg inflammation and woody induration in patients with chronic venous or lymphatic hypertension [1]. Lipodermatosclerosis takes grade 4 on CEAP scale which is a graded scale that includes six grades and classifies venous diseases according to its severity based on clinical, etiologic, anatomic and pathologic aspects [2,3]. Lipodermatosclerosis may present as

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an acute or as a chronic (longstanding) condition. Chronic lipodermatosclerosis (CLDS) may follow an acute episodes or develop gradually [4].

Acute lipodermatosclerosis (ALDS) presents as episodes of painful inflammation in the inner leg above the ankle, resembling cellulitis [5]. The affected area is painful and inflamed, red or purple in color with poorly demarcated plaques, often with indurated and edematous skin of the medial calf. Some thickening of the skin can be felt. Patients with acute lipodermatosclerosis are mainly middle-aged [4]. Histologically, ALDS is mostly a lobular panniculitis with increased fat sclerosis, membranous necrosis and microcysts [6].

Common findings in chronic lipodermatosclerosis (CLDS) include pain, hardening of the skin, localized thickening, moderate redness, increased pigmentation, small white scarred areas (atrophie blanche), increased fluid in the leg (edema), varicose veins and leg ulcers. Chronic lipodermatosclerosis also predisposes to venous or stasis eczema [4].

Unless the underlying cause of the LDS is treated, the patient is at a high risk of developing a painful and potentially chronic venous leg ulcer [7]. Patients experience increased stress, pain, decreased quality of life and difficulty in coping with the symptoms and manifestations of the disease. In addition to the psychosocial problems, the financial costs can be significant [8].

In lipodermatosclerosis, the microvascular network is affected by the consequences of venous hypertension [9]. Several groups suggest that the subcutaneous vasculature is the first to be affected, leading to ischemic fat necrosis and panniculitis [10,11]. Whereas others propose that the papillary plexus in the upper dermis of the skin is initially affected [9,12,13].

The cellular and molecular mechanisms leading to the formation of LDS from venous hypertension are not known; it is likely to be multifactorial. Raised intravascular pressure, produced as a consequence of venous hypertension, is known to affect the capillary network of the skin in a manner as to cause enhanced filtration of fluid, leakage of plasma proteins such as fibrinogen and extravasation of erythrocytes [1,9].

Since the fibrinolytic activity of the blood and the tissues is deficient in patients with venous hypertension, any fibrinogen which is converted to fibrin in the interstitial spaces is less likely to be broken down or reabsorbed [14].

A sheet of fibrin appears to allow carbon dioxide to pass through it relatively freely but this sheet is relatively impermeable to the passage of oxygen, which leads to ischemia and destruction of tissues [15,16]. Moreover, patients with LDS may produce lower levels of plasminogen activator coupled with a simultaneous presence of elevated levels of its inhibitors in blood and tissues [17]. There is clear evidence of leukocytes' activation in venous disease and many inflammatory mechanisms are up-regulated in the skin [18].

2. Ethical consideration

The study protocol was explained in details for each patient before the initial assessment and signed informed consent was obtained from each patient before enrollment in the study (or their families)...This study was approved by the meeting of the department of Physical therapy for surgery and the ethics committee of the Faculty of Physical Therapy, Cairo University. The study is also carried out in accordance with the code of Ethics of the World Medical Association (Declaration of Helsiniki) for experiments involving humans.

3. Patients and methods

3.1. Subjects

This controlled randomized study was conducted to determine the effect of U.S. waves in controlling pain and skin durability in patients suffering from lipodermatosclerosis. Forty patients with lipodermatosclerosis had met the inclusion and exclusion criteria. The age ranged between 42 and 65 years old. They were divided randomly into two equal groups. Following the baseline evaluation of each patient, a closed envelope was randomly selected that contained the patient's group allocation. Group (A) the study group, received continuous ultrasound wave (3 MHz – 3 sessions/week), in addition to the routine treatment which consisted of grade 2 compression stocking at pressure from 30–40 mmHg. Patients wore compression stocking mainly during weight bearing conditions. Patients were advised to try to decrease weight bearing as much as possible during the treatment period, and to do circulatory exercises for 15 min at least 5 times/day. Group (B) the control group, received placebo ultrasound wave in addition to the same routine treatment. Patients were excluded if he/she had skin malignancy, open wound or ulcer at the site of treatment, skin infection at the treated area, psychological or mental problems, occupational and/or above-average recreational weight bearing requirements, dermatological condition rather than LDS at the treatment site as well as one of the ultrasound contraindications. Patients who received previous physical therapy program for LDS were also excluded from the study.

3.2. Methods of evaluation

Primary medical examination was done to every patient to get a complete medical picture of the health status of the patient and to know if the patient was able to undergo the study or if there were any contraindications.

Measurements were performed under standardized conditions taking into consideration that:

- Measurements were carried out by the same investigator.
- The same area was assessed before and after therapy for each patient.
- The patients were given 10 min. to adapt to room conditions and this constant for all patients.
- Measurements were always carried out with the patient in a resting position.

3.2.1. Pain assessment

Patients were asked to determine their degree of pain using the *numeric rating scale* (*NRS*); pre-treatment, after 4 weeks of the treatment (Post I) and after 8 weeks, at the end of the study (Post II) to determine the severity of pain. NRS is a scale with approximately ten severity grades. The NRS is graded from 0 (no pain) to 10 (maximum pain). Grades of NRS were explained for patients for more accurate expression of their pain degree.

3.2.2. Skin hardness

Durometer was also used to determine the state of LDS skin. Durometer (Model Digital DD-3, Type 00, Rex Gauge, IL, and USA) was used pre-treatment and post-treatment (after 8 weeks) for the measurement of skin hardness. Skin hardness was conducted on two sites, 5 and 10 cm superior to the medial malleolus of the ankle. For the measurements, subjects were laying on their lateral side (side laying position) with the required leg lying in contact with the examination table in a semi-flexed position with the ankle supported by a pillow. This position allowed the durometer to be both perpendicular to the leg and table top and allowing the use of gravity for skin indentation without any angulations. These sites were chosen because of their presence in the affected area, not over bony prominence and were easily standardized. The durometer usually was placed perpendicular on the skin without exerting any pressure in order to avoid any external force using the effect of gravity.

3.3. Treatment procedure

Patients were asked to stop any drug that had any effect on the present study before the beginning of the study by at least 2 weeks for a topical one, and by 4 weeks for an oral one.

All patients were instructed to wear grade 2 compression stockings (30–40 mmHg) [1]. Also patients were asked to follow the dermatologist instructions (as sterilizing the affected area continuously, prevention of any increase in weight and prevention of prolonged weight bearing), that was started before the beginning of the treatment procedure by at least 2 weeks and until the end of the study.

Group (A): study group

Patients received 3 MHz continuous ultrasound (Ultracombi-707 ultrasonic device is a therapeutic U.S. device manufactured by Dae Yang medical CO. Ltd,Korea), 3 sessions/week for 8 weeks. We began with an intensity of 0.7 W/cm^2 for 5 min per 50-cm^2 area (in first 2 weeks) to capture thermal effects of U.S., and then increased the intensity to 1 W/cm^2 for 8 min per 50 cm^2 (for the following 2 weeks) then the intensity was increased to 1.5 W/cm^2 for 10 min per 50 cm^2 (in the next 4 weeks) to capture both the thermal and non-thermal effects of the U.S., in addition to the previously mentioned routine treatment.

Group (B): control group

Patients received a placebo U.S. therapy plus the previously mentioned routine treatment.

4. Statistical analysis

Statistical analysis was performed using The Statistical Package for Social Science (SPSS). For each variable the mean and standard deviation were calculated. Paired *T* test was used to compare the dependent variable (pain and skin hardness), within each group to detect the level of significance. Unpaired *T*-test was applied to compare the dependent variable (pain and skin hardness), and independent variables (age, sex, and BMI) between the two groups to detect the level of significance. *P*-values less than 0.05 were considered to be statistically significant, NRS was compared at the start, after four sessions and at the end of the treatment using ANOVA test for dependent variables.

5. Results

5.1. Demographic and clinical characteristic of the patients

As revealed from (Table 1), There were no statistical significant differences between the mean values of the two groups concerning general characteristics of age, sex and Body mass index at the beginning of treatment. ($P > 0.05$). Table 2 represents the Frequency of some accompanied medical conditions in both study and control groups.

5.2. Results of NRS (numerical rating scale) for the two groups (pre, post I and post II) are included in Table 3 and Figs. 1,2

The results of this study revealed that there was no significant difference in pain sensation measured by NRS between control and study groups at the beginning of the study ($P > 0.05$). Comparison between control and study groups post I, and after 8 weeks (post II) revealed that there was a significant decrease in pain sensation measured by NRS in the study group compared to the control group (*P* values = 0.0001 and 0.0001 respectively). Pain sensation decreased by 53.1% (*p* value = 0.0001) after 4 weeks of US treatment, while application reduction in pain sensation by 87.58% (*p* value = 0.0001) after 2 months of treatment *in the treatment group.*

5.3. Results of skin hardness for the two groups (pre and post-treatment) are included in Table 4 and Fig. 3

It was found that application of U.S. up to 2 months achieved a statistically significant decrease in skin hardness at the level of 5 cm measurement and 10 cm measurement above the medial malleolus by 21.56% and 19.4% respectively in the

Table 1 Statistical analysis of the demographic and clinical characteristics of patients between the two groups at the beginning of the study.

Groups	Group (A) (n = 20)	Group (B) (n = 20)	*P*-value
Variables			
Age (years)	61.53 ± 12.22	58.8 ± 12.13	0.51*
Sex (male/ female)	9/11	10/10	0.89*
BMI	29.36 ± 4.98	28.66 ± 4.48	0.64*

X = Mean, SD = Standard deviation, *P*-value = Probability level, BMI = Body Mass Index.
* Non-significant ($P > 0.05$).

Table 2 Frequency of some accompanied medical conditions in both study and control groups.

Item	Study	Control
Diabetes	14 (70%)	12 (60%)
Hypertension	14 (70%)	11 (55%)
Smoking	4 (20%)	6 (30%)
Varicose veins	15 (75%)	12 (60%)
Valve incompetence	11 (55%)	11 (55%)
Old thrombosis	7 (35%)	4 (20%)

treatment group while the control group skin hardness decreased by 2.43% and 3.04% respectively (P Value = 0.0001).

Fig. 4(a and b) shows the difference between an affected area pre and post application of ultrasonic while Fig. 5(a and b) shows the difference between an affected area pre and post for the control group.

6. Discussion

Ultrasonic (US) treatment of LDS was reported for the first time more than 30 years ago by Rowe and Cantwell [19]. Our results prove the efficacy of the U.S. treatment in improving skin tone and pain sensation in patients with lipodermatosclerosis. Throughout the study, there was no complain from any adverse effect of ultrasonic treatment, whereas, five patients (12.5%) complained from feeling pain due to wearing compression stocking but they completed the study.

The therapeutic effects of ultrasonic include reducing inflammation and swelling, increasing soft tissue extensibility, speeding metabolism, improving blood flow, reducing nerve root irritation, breaking up scar tissue and adhesions, creating a deep heat to a localized area much deeper than can be achieved with a hot pack and facilitating healing at the cellular level [20–22].

Our results were supported by many previous studies, such as that of Diona and colleagues [1] who proved that continuous ultrasonic application to LDS patients, significantly reduced skin hardness by 60%, reduced Erythema by 46% in 7 of the 9 legs with erythema indices and rapidly alleviated symptoms.

Ultrasonic effect on LDS may be attributed to the immunomodulatory and anti-inflammatory effects of ultrasound

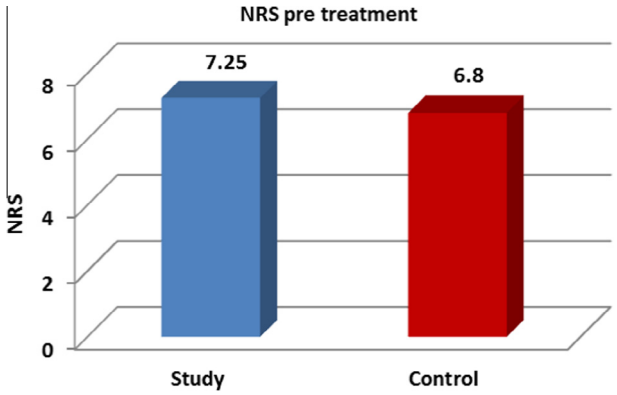

Figure 1 Comparison of NRS (pre-treatment) between both groups (study and control).

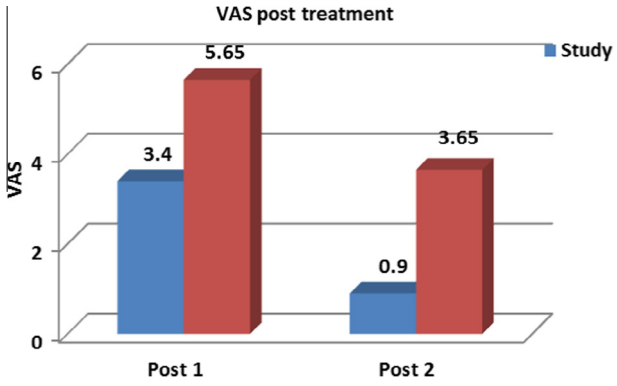

Figure 2 Comparison of NRS (post I and post II) between both groups (study and control).

Table 3 Results of NRS (numerical rating scale) for the two groups (Pre, Post I and Post II).

Groups	Mean			Standard deviation			F-value	P-value	Percent of improvement
	Pre	Post I	Post II	Pre	Post I	Post II			
Group A	7.25	3.4	0.9	1.25	0.82	0.71	375.68	0.0001	87.58
Group B	6.8	5.65	3.65	1.43	1.66	1.42	55.12	0.0001	46.32

Table 4 Results of skin hardness for the two groups (Pre and Post).

Groups	Level of measurement	Mean		Standard deviation		t-Value	P-value	Percent of improvement (%)	Sig.
		Pre	Post	Pre	Post				
Group A (study group)	At 5 cm	20.4	16	1.75	1.16	11.18	0.0001	21.56	S
	At 10 cm	21	17	1.29	1.16	12.32	0.0001	19.04	S
Group B (control group)	At 5 cm	20.5	20	1.67	1.29	1.56	0.13	2.43	NS
	At 10 cm	21.35	20.7	1.03	1.45	1.68	0.1	3.04	NS

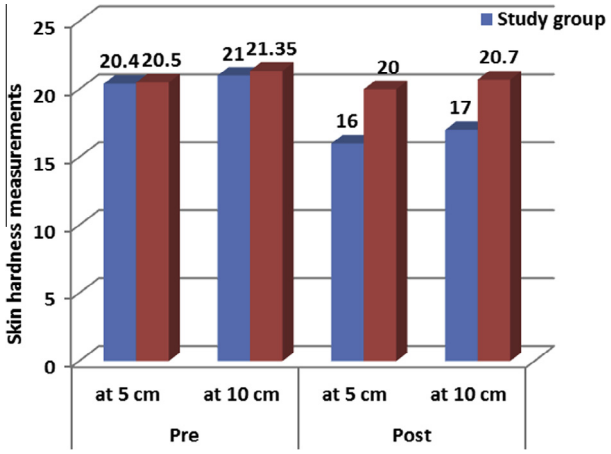

Figure 3 Comparison between pre and post treatment mean values of skin hardness of both groups (study and control).

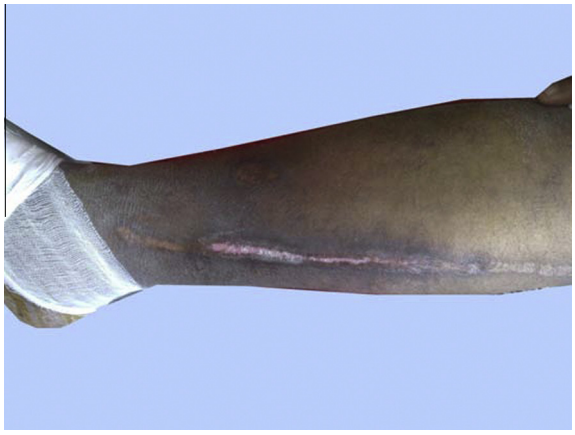

Figure 4a Shows an affected area pre-application of ultrasonic for a case with lipodermatosclerosis.

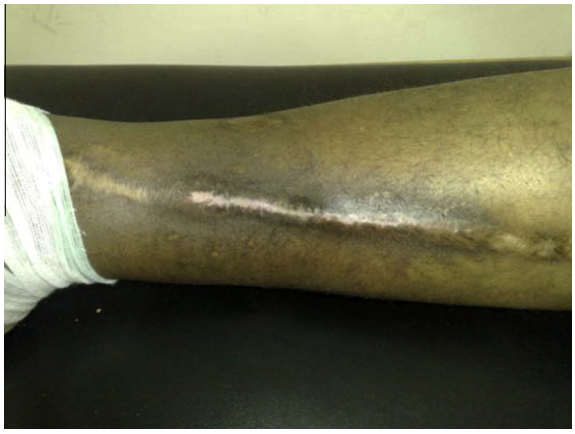

Figure 4b Shows an affected area post-application of ultrasonic for a case with lipodermatosclerosis.

waves, up regulation of collagen-degrading matrix metalloproteinase and promotion of circulation [23–25].

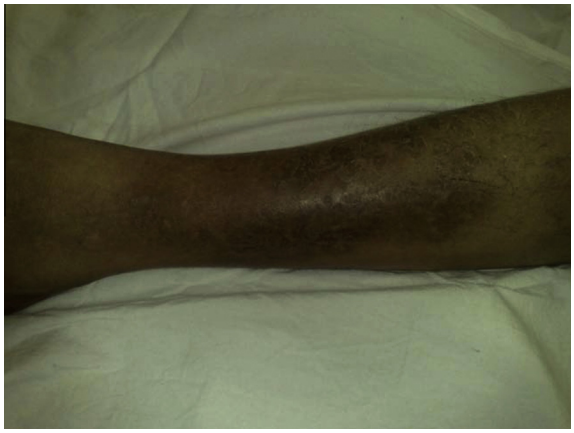

Figure 5a Shows an affected area pre-application of placebo ultrasonic for a case with lipodermatosclerosis.

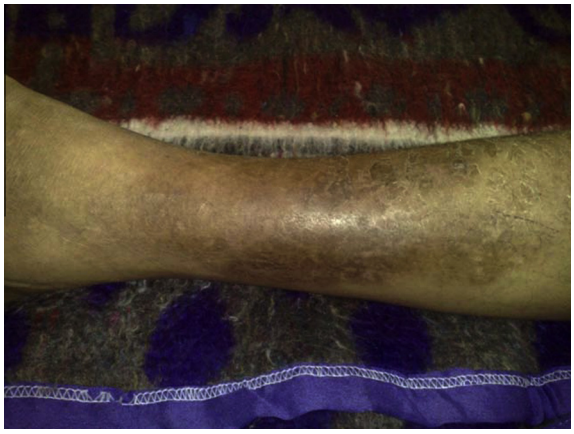

Figure 5b Shows an affected area post-application of placebo ultrasonic for a case with lipodermatosclerosis.

This may also be due to speeding up metabolism and improving blood flow Promoting angiogenesis, Stimulation of fibroblast proliferation with ultrasound, and increase in collagen deposition,

It may lead also to reduction of inflammation, swelling and nerve root irritation, increase in soft tissue extensibility, facilitating healing at a cellular level and reversal of both the fibrotic and inflammatory changes of LDS [1,20,26–28].

Also it was found that pulsed ultrasonic can promote circulation. Application of ultrasound on alternate days for a period of either 1 or 3 weeks improved arterial blood flow which may improve any condition resulting from poor blood supply [20,25]. Other effects have also been observed in vivo studies, such as changes in the plasma membrane and in intracellular organelles such as lysosomes and mitochondria [27].

However, our results disagreed with Flemming and Cullum [29], and Baba-Akbari Sari et al. [30],. Flemming and Cullum [29] suggested that, there might be some improvement in the healing rate of venous ulcers associated with the use of therapeutic ultrasonic, though no trial found a significant effect of ultrasound therapy in the healing of venous leg ulcers. These results should be taken with caution as there were only seven

poor quality trials with a total of 274 patients involved, making it difficult to determine clinically important effects.

7. Conclusion

Within the limitations of the present study, the notable conclusions are:

The ultrasound therapy (U.S.) with previously mentioned parameters is a useful approach in controlling lipodermatosclerosis; in expression of reducing pain, reducing skin thickness, and improving of the appearance.

Conflict of interest

The authors declare no conflict of interest. There is no financial or personal relationship with other people or organizations that could inappropriately influence this research.

Acknowledgments

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