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MICROWAVE: AN ALTERNATIVE TO ELECTRIC HEATING IN THE TREATMENT OF PERIPHERAL LYMPHEDEMA

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ABSTRACT

The results of a new method of treating chronic lymphedema with heat, using microwaves, are described in 98 patients with peripheral lymphedema. Thirteen had bilateral lymphedema and were included only to provide additional evidence of the lack of side-effects using this technique. The remaining 85 patients showed a significant ($p<.001$) reduction in the amount of peripheral edema with edema reduction >50% in three-fourths of the patients. The incidence and severity of secondary acute inflammation ("erysipelas") were also sharply reduced ($p<.001$). The microwave method of heat application has a number of advantages over an older technique which used electrically-powered heating elements.

We have used heat and bandaging to treat chronic lymphedema of the extremities since 1964 (1,2). In our experience, this treatment approach gives the best results with an "effective rate" of over 90% after 5 courses of therapy. After repeated applications of heat, the temperature of the skin and subcutaneous tissue of the diseased limb is temporarily raised and suggests that local tissue metabolism is activated along with potentiation of lymphatic regeneration and increased lymph drainage.

However, heating by means of electrically-powered elements has major drawbacks. The high temperature (>80°C) within the chamber makes patients very uncomfortable, with intense sweating and a rise in the general body temperature of 0.5-1°C. Many prolonged courses of treatment are also required.

To circumvent these limitations, we developed an alternative method of heating, using microwaves, in 1983. Since then, 98 patients with chronic lymphedema of the extremities have been treated with highly encouraging results. The microwaves penetrate the tissues for a considerable depth with ease, and are eventually absorbed by interstitial fluid which becomes warmed. Hence, the edema fluid itself is the target tissue, and only edema fluid and adjacent tissue are heated to any appreciable extent. The amount of heating is proportional to the watts and the time applied, and is inversely proportional to the mass of the limb.

MATERIALS AND METHODS

The microwave oven consists of a cylindrical chamber, containing three radiation antennae. These emission units are attached to the inner wall at 120° to one another. Total energy generation is up to 180 watts. In this series, the average energy applied was 120 watts. The frequency is 1.25×10^9 hertz. The chamber is completely lined with lead except for an opening at one end to accommodate the extremity which is laid on a frame splint in the middle of the chamber. The limb to be treated is wrapped with a piece of shielding cloth at the opening in such a

Table 1
Average Changes of Limb Circumference (in cm)
Before and After Microwave Treatment (85 Cases)

Courses	No. of Cases	BEFORE TREATMENT Normal	Lymph-edema	Diffce.	AFTER TREATMENT Normal	Lymph-edema	Diffce.	Limb Edema Resolution %
1	85	180.8	202.7	21.8	180.8	194.8	14.0	35.8
2	43	183.5	203.7	20.2	182.7	193.5	10.8	46.4
3	16	188.2	209.5	21.2	188.4	196.2	7.8	61.0

way that leakage of microwaves is minimal. The treatment time is 30 minutes each day for a total of 15 days, and often the cycle is repeated in 2 months. Further courses are given, however, if the outcome is less than satisfactory. In this series, a single course of heating was given to 28 patients, two courses to 50 patients, and three courses to 20 patients. After each treatment and during the intermission period, compression bandages are continuously worn during the day but removed at night.

We earlier found (1,2) that the optimal temperature to be reached in the subcutaneous tissue was 39-40°C. To ensure that this temperature was attained, a deep tissue thermocouple was passed to 1.5cm below the skin. The watts employed were adjusted to ensure that this optimum was maintained which was reached after only 5 minutes.

These 98 patients had filarial lymphedema and included 52 females and 46 males with an age range from 7 to 77 years. Ninety-one patients had lymphedema of the legs (50 left, 29 right, and 12 bilateral). The remaining seven patients had lymphedema of the arms; one was bilateral. Statistical analysis was performed only on the 85 patients with single-limb lymphedema. Those with bilateral lymphedema were too few for statistical evaluation and were included for further evaluation of side-effects.

The effectiveness of therapy was determined by the improvement in lymphedema and by the decrease in frequency of attacks of secondary acute inflammation ("erysipelas"). Regression with lymphedema was quantified by measuring limb volume using water displacement and by five circumference measurements (midfoot, ankle, mid-leg, just above and also 10cm above the knee). Results were graded as: "excellent" (completion resolution of edema), "good" (edema reduction >50%), "fair" (edema reduction <50%), "poor" (no change or increase of edema).

RESULTS

Tables 1-4 show the marked reduction in the amount of edema after microwave heating and compression bandaging. These results are all significant at the 0.1% level when compared against zero alteration. Of the 98 patients, 70 had a history of secondary acute inflammation ("erysipelas"): 43 had 1-5 episodes per year, 14 had 6-10, 9 had 11-15, and 4 had over 16. In 25 patients, these inflammatory episodes were considerably reduced by two courses of treatment, and when it did supervene, the severity appeared less intense.

Table 2
Grading of Edema Resolution (85 Cases)

Courses	No. of Cases	Grade I (Excellent) Cases	%	Grade II (Good) Cases	%	Grade III (Fair) Cases	%	Grade IV (Poor) Cases	%
1	85	12	14.1	17	20.0	47	55.3	9	10.6
2	43	9	20.9	13	30.2	20	46.5	1	2.3
3	16	3	18.8	9	56.3	4	25.0	0	0

Table 3
Limb Volumes (ml) Before and After Microwave Treatment (85 Cases)

Courses	No. of Cases	BEFORE TREATMENT Normal	Lymph-edema	Diffce.	AFTER TREATMENT Normal	Lymph-edema	Diffce.	Limb Edema Resolution %
1	85	5,369	6,881	1,512	5,344	6,532	1,188	21.4
2	42	5,413	6,700	1,377	5,424	6,315	890	35.4
3	16	5,606	7,072	1,466	5,656	6,278	621	57.6

No skin burns or other untoward side effects were observed. There was no elevation of systemic body temperature after use of the microwave chamber. Patients were comfortable and did not sweat. No changes were detected in the standard hemogram, chemical tests of liver function or urinalysis.

A characteristic patient and the response to microwave heat and bandaging is shown in *Fig. 1.*

DISCUSSION

Although a heat treatment method has been proposed for peripheral lymphedema without appropriate untreated controls, it is well known that filarial lymphedema does not spontaneously regress (3,4); indeed, it usually gets worse. This progression may be slow or quite rapid if complicated by repeated episodes of secondary acute inflammation ("erysipelas"). Even when secondary acute inflammation has subsided, the patient is left in a worsened physiologic condition. For these reasons and our previous experience demonstrating that heat consistently improves such patients (1,2), we considered it to be unethical to maintain a group of patients without therapy.

The results of our microwave heat treatment are limited to the past four years and thus longer-term follow-up is not possible. On the other hand, our previous experience with heat application for lymphedema has been in use for over 20 years. Although many of the patients live far from Shanghai and checking of long-term results is therefore difficult, it is noteworthy that those patients we observed have generally continued in the same improved physiologic state as when they finished the final course of heat treatment. Accordingly, we are confident that the microwave heat-bandage technique promotes prolonged benefit.

Heating with microwaves offers distinct advantages to heating with electrically-powered heating elements. Thus, (a) the ambient temperature of the microwave chamber is much less elevated and only the edema fluid and surrounding tissues are heated. Accordingly, patients are more comfortable without sweating or elevation of whole-body temperature. This technique is especially useful in the management of patients with recent skin grafts which are intolerant to electric heating; with microwaves, the grafted area can be treated without risk of burning. (b) The therapeutic time course is shortened. Whereas with microwaves, deep tissues reach the therapeutic optimal temperature (39-40°C) after only five minutes, with electrically-powered heating elements, 30 minutes are usually needed to reach this temperature level. Thus, in-

Table 4
Grading of Volumetric Reduction (85 Cases)

Courses	No. of Cases	Grade I (Excellent) Cases	%	Grade II (Good) Cases	%	Grade III (Fair) Cases	%	Grade IV (Poor) Cases	%
1	85	10	11.8	13	15.3	54	63.5	8	9.4
2	42	4	9.5	13	31.0	20	47.6	5	11.9
3	16	1	6.3	9	56.3	6	37.5	0	0

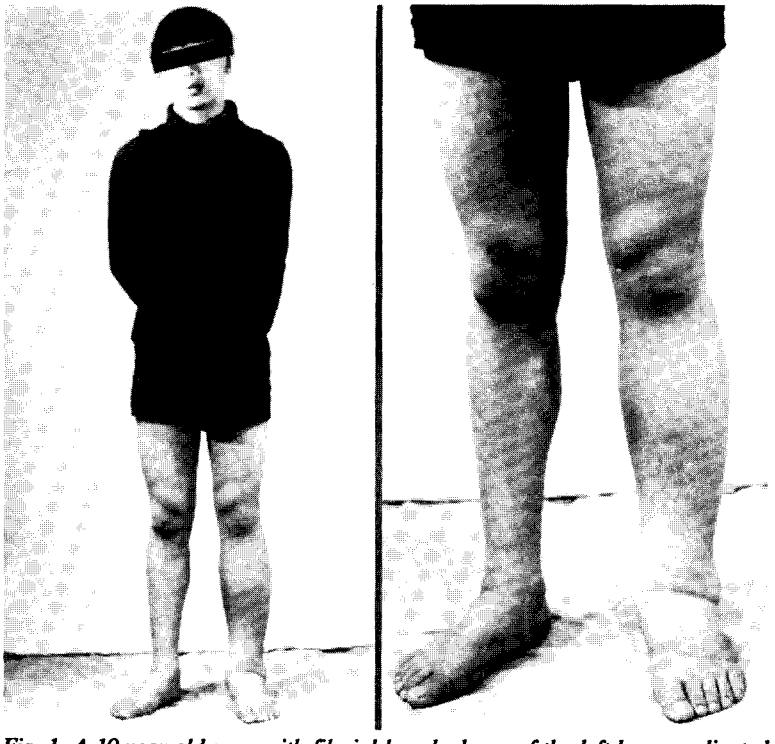

Fig. 1. A 19-year-old man with filarial lymphedema of the left leg complicated by frequent secondary attacks of acute inflammation and pyrexia to 39°C.

Fig. 2. Same patient after three courses of microwave treatment and compression bandaging. Leg swelling has disappeared, and he remains edema-free at 10 month follow-up.

dividual treatment sessions are decreased from 60 to 30 minutes, and overall the whole course from 20 to 15 days. (c) Finally, there is less energy consumption. With microwaves, an average of 1,350 watts is needed for each course of treatment; the "old" method used 28,000 watts.

Although this treatment was effective in the vast majority (a 50% reduction in edema in three-fourths of the patients and reduction in number and severity of secondary acute inflammatory attacks), more treatment courses might produce even better clinical outcomes.

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