The use of stable cavitation in non-invasive treatment of localized lipomas

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SUMMARY

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The stable cavitation produces partial or total cellular membrane ruptures, with a permeability increase of adipocytes membranes. The adipocytes contents (fatty acid, triglycerides and cholesterol) go to the intercellular space. The clearance of these substances from the interstitial liquid is provided by the lymphatic and venular system. As model to prove the effect of ultrasounds on adipocytes we chose to treat several lipomas. A lipoma consists of a capsulated aggregation of adipocytes and its volumetric reduction can definitely prove the ultrasound effectiveness on adipocytes. We chose twenty patients affected by localized lipomas and treated them with an ultrasound device working at 33 ± 3 KHz provided with two probes with different designs. The probe design greatly influences the deepness of ultrasound activity. Meanwhile the sweeping of the ultrasound wave was mainly constant generating a stable cavitation. The evaluation of lipomas was done with a sonography before the treatment, followed by a post-treatment control done thirty days later. In all patients, after the first treatment, we found approximately a reduction of one quarter in volume. Further studies will clarify how many sections we need in order to have a stable reduction of the lipoma and whether any infiltration of lipoma may give better results.

KEY WORDS: *Stable cavitation, Ultrasounds, Lipomas*

Stefano Verardi

Introduction

Superficial lipomas are benign mesenchymal neoplasms composed of mature adipocytes, usually surrounded by a thin fibrous capsule [1].
Microscopically they are composed of lobules of mature adipocytes separated by fibrous septa. The back, shoulders, and upper arms are the most common locations [2]. Superficial lipomas appear as soft, painless, well-delineated and mobile masses [3]. They are often asymptomatic except in case of masses compressing nervous-vascular structures [4]. Most of them appear in individuals between the age of 40 and 60 years. Lipomatosis is thought to be secondary to a defect in the lipid metabolism. Most lipomas demonstrate karyotypic abnormalities involving the chromosome's branch 12q [2]. Sometimes, lipomas may be the results of a previous trauma [4]. Lipomas are capsulated masses with a three-dimensional conformation: width, height and depth. Sonography is the first approach to the diagnosis of lipomas, is a low coast procedure compared to magnetic resonance (MR) [3]. When a lipoma is superficial, the sonography alone may be sufficient for the diagnosis. Magnetic Resonance imaging is adapt to recognise the lipomas situated deep to the superficial fascia [5]. Traditional approaches to lipomas are treatments based on surgery or liposuction. Surgical scars are rarely accepted from surgery patients while liposuction is often associated with massive bleeding due to the rich vascularisation of the lipomas.
An alternative approach to the treatment of these neoplasms is the application of ultrasounds; this methodic is non-invasive, safe,

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effective and without any scar. In our study we choose ultrasounds to treat lipomas as a model to prove the effectiveness of ultrasounds on adipocytes. A lipoma can be a valid specimen for the application of stable cavitation induced by ultrasounds due to its anatomic conformation. The fibrous capsule of the lipoma retains the cavitated mass of adipocytes and the outcome of the treatment can be very well evaluated.

Materials and methods

We treated 20 patients (17 females and 3 males) with superficial lipomas in different areas of the body (3 thigh, 8 shoulder, 3 arm, 4 lower arm, 1 cheek and 1 breast region lipoma) with a device generating ultrasounds at 33 ± 3 KHz, with a pressure included between 4 and 80 kPa (kPascal). The device, which we may call "Resonance Pressure Generator", was using two different probes with a different design, one concave (Figure 1) with the focus point at 0,5/1,5 cm from the skin and the other flat (Figure 2) with the focus point at 1,5/2,5 cm. The average age of the patients was 48 years old. The average dimension of the lipomas was 54,85 mm. All lipomas were screened, before and after the treatment by sonography to evaluate the reduction of the cavitated mass. For each lipoma the sonography reports 3 dimensions (height, depth and width).

Many authors [6-8] in literature used the application of ultrasounds to treat localized fatty deposits. Only *Ceccarelli M. et al.* [9, 10], as reported in literature, used ultrasounds with a device working at different KHz from ours device to treat lipomas. They usually infiltrated the mass before the treatment; in our study we didn't infiltrate the lipoma. We used two different probes and the application time was 8 minutes for each lipoma: 5 minutes with a flat probe and 3 minutes with a concave probe. We applied the probe strongly adherent through a sonography gel and exactly perpendicular to the lipoma's surface. We also used to squeeze the neoplasm every 10 seconds during the treatment. The squeezing allows obtaining a cavitation on different deepness of the lipoma. We treated each lipoma only one time and we checked the reduction of dimension with sonography after one month.

Figure 1.

Concave probe: focus point at 0,5/1,5 cm from the skin.

Figure 2.

Flat probe: focus at 1,5/2,5 cm from the skin.

Results

After the treatment the average reduction percentage of the lipoma's dimension screened by sonography, was 25% (20% minimal and 27 % maximal reduction).

We choose to analyze only the major dimension of the lipomas because it was the best significant measure to calculate the reduction of the neoplasm. All the dimensions of lipomas were expressed in millimetres (Table 1).

We obtained the best result with a lipoma of the lower arm, in a 43 y.o. female patient; the initial dimension of the neoplasm before the treatment was 35 mm (Figure 3). After the ultrasounds treatment the dimension showed by the sonography was 25,5 mm (Figure 4).

Table 1.

The table shows all pre-treatment and post-treatment dimensions of lipomas.

		AGE	LOCALIZATIONS	INITIAL DIMENSIONS	REDUCTION	FINAL DIMENSIONS
1	F	45	THIGH	77	18	59
2	F	75	SHOULDER	48	12	36
3	F	43	LOWER ARM	35	9,45	25,5
4	F	45	THIGH	38,5	9,4	29,1
5	F	58	ARM	92	19,32	72,68
6	F	39	ARM	75	16,5	58,5
7	F	56	SHOULDER	60	14,1	45,9
8	F	53	BREAST REGION	120	24	96
9	M	30	CHEEK	30	7,65	22,35
10	F	45	SHOULDER	30	7,8	22,2
11	F	42	SHOULDER	57	14,5	42,5
12	F	42	LOWER ARM	45,6	11,8	33,8
13	F	77	SHOULDER	60	15,18	44,82
14	F	60	SHOULDER	60	15,18	44,82
15	F	51	THIGH	50	12,7	37,3
16	M	48	SHOULDER	37	9,4	27,6
17	F	30	ARM	47	11,8	35,2
18	M	37	SHOULDER	48	12,72	35,28
19	F	43	LOWER ARM	42	10,9	31,1
20	F	52	LOWER ARM	45	11	34
AVERAGE		48,55		54,855	13,17	41,685

The average initial dimension of the lipomas was 54,85 mm. After the first treatment the average dimension of the lipomas was 41,68 mm. (Graphic 1) All the dimensions were screened, before and after one month from the treatment, with sonography. The treatment did not generate any collateral effects, local and systematic diseases. The patients very well accepted the application of ultrasounds although the increase of skin temperature surrounding the

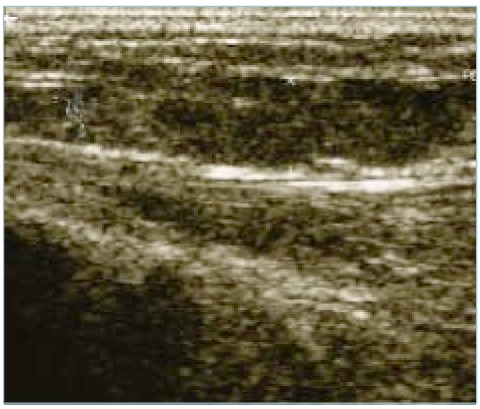


Figure 3.

Pre-treatment echograpy: a lipoma of the lower arm. Initial dimension: 35 mm.

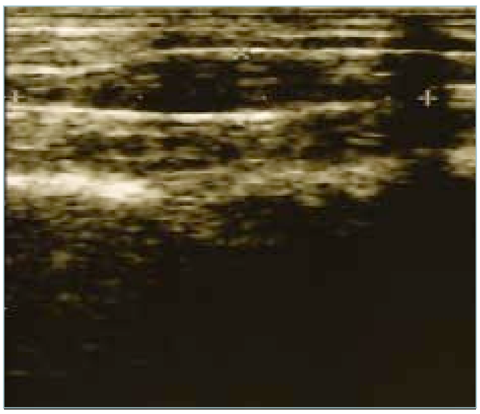


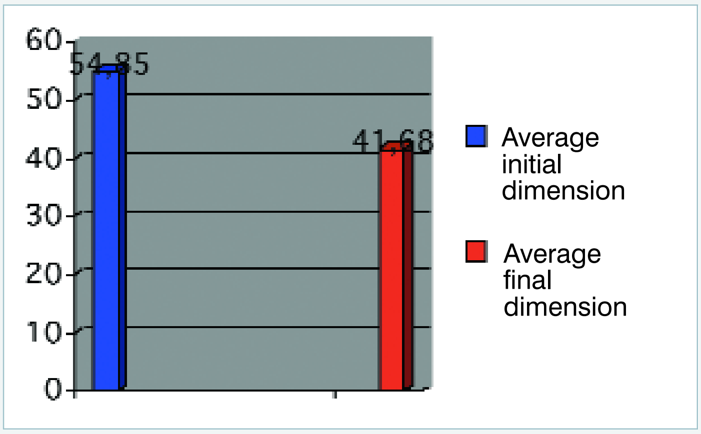
Figure 4.

Post- treatment echography: final dimensions 25,5 mm.

lipoma during the treatment. As a clinic result all lipomas, after treatment, showed a reduction of their consistence at the superficial palpation; they appeared softer than before the treatment.

Discussion

The ultrasounds may generate 4 biological effects: micromechanical, mechanical, thermal and cavitational effect. With the micromechanical and mechanical effects [11] the ultrasounds produce movements, ruptures and shape modifications of the biological molecules; many of these molecules may loose their functions. The thermal effect [12, 13] of the ultrasounds depends on the Joule Effect. The mechanical wave of the ultrasounds determines molecular movements that increase the kinetic energy of molecules. The kinetic energy determines inside tissues the activation of a Joule effect. According to the Joule's law the potential energy of electric charges in movement is partially converted into heat with an increase of the temperature of biological materials. When this temperature exceeds 37 C°, protein denaturation starts. The loss of many cellular functions starts with protein denaturation. The cavitational effect [11, 14] of ultrasounds is activated by a resonance pressure generator. The cavitation is a phenomenon that takes place in a liquid when it's subordinated to a strong depression. It consists in the creation of gas (or vapour) bubbles generated in a liquid inside the same liquid. The cavitation is a physical phenomenon that is generated by high intensity ultrasounds. The ultrasounds penetrating through liquids and solids (as in the human body) may separate molecules. This phenomenon, when the intensity of ultrasounds is sufficient, generates micro bubbles inside the interstitial liquid and inside the cell, especially in giant cells. The micro bubbles generated inside the interstitial or intracellular liquid (in case of giant cells) implode and quickly disappear. In a few microseconds this implosion generates an enormous pressure and a great heat exchanges which expands around these micro bubbles [15, 16]. Our study, according to the literature, has confirmed the possibility to obtain a stable and focalized cavitation during the treatment of lipomas, which brings a reduction of their dimensions. This reduction is obtained also because we used probes with different designs. In fact the probe design greatly influences the deepness of ultrasound activity. Lipomas and localized fat deposits are histological equivalent in matter of adipocytes composition, the only difference is that the second ones are not surrounded by any fibrous capsule and do not contain fibrous septa. Ultrasound treatment, then, can be used in any area of the body where fat deposits are present. There are many effects of the cavitation on the adipocytes. The cavitation may generate partial or total rupture of the cellular membranes, adipocytes's cellular membrane permeability increasing, spreading out in the interstitial spaces of the adipocytes's content (fatty acids, cholesterol and glycerine) that is removed through the lymphatic and venous system. The cavitation may produce microscopic effects [8, 17]. After 1 minute of treatment with ultrasounds there is formation and exponential increase of bubbles and serum. The serum comes from the emulsification of the fats. After 2 minutes, through the confluence of many implosions, the destruction of the adipocytes starts. After 3 minutes the areas of fat tissue destruction increase. After 4 minutes there is the maximal emulsification inside the damaged adipocytes.



Graphic 1.

Average initial dimension and average final dimension, 1 month after the treatment.

Conclusions

The cavitation produces biological effects on adipocytes due to the mechanical movements (collisions) inside the cells depending on the density of the applied power and the used frequency and due to the chemical effect

depending on the separation of long and complex molecules in shorter chains and in ionization of some molecules [18]. All these effects generate sequential destruction of fat cells.
The adipocytes are the first cells destroyed by the cavitational effect because their wall has the greatest tension.
With all these scientific considerations and with the clinic results that we obtained in our study, we can assume that the cavitation is an highly selective mechanism and it's strongly adapt to destroy the adipocytes localized in a capsulated mass as a lipomas and in localized fat deposits of any area of the body.
Further studies will clarify how many sections we need in order to have a stable reduction of the lipoma and whether any infiltration of lipoma may give better results.

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