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METHODS

Assessment of the Efficacy of Treatment of Hemangiomas

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Assessment of the aftereffects of cryoexposure and ultrahigh-frequency cryoexposure on hemangioma tissue of various types, cavernous and squamous, showed a higher cryogenic effect in hemangiomatous tissue preexposed to ultrahigh-frequency waves. A quantitative criterion is proposed for assessing the efficacy of the studied methods of exposure.

Key Words: *mechanical parameters of the skin; hemangiomas*

Recent reports demonstrate the efficacy of treating children with hemangiomas by cryogenic and ultrahigh-frequency (UHF) cryogenic methods [6,8]. This study was undertaken to develop quantitative biomechanical criteria for comparing the efficacy of hemangioma treatment by two methods: cryogenic and UHF-cryogenic.

MATERIALS AND METHODS

An acoustic analyzer of tissues, a device permitting the assessment of biomechanical properties of the skin by recording the rate of propagation of ground waves (5-6 kHz frequency), was used for objective quantitative evaluation of the skin [5].

Hemangiomas were treated by local destruction with a device of a priming type by the standard method [4]. A combined method of UHF-cryodestruction was used for the treatment of cavernous hemangiomas. The presence of cavernous hemangiomas with a substantial subcutaneous part, often of a complex localization, which had failed to be cured by other methods was an indication for applying this method. Hemangiomas were exposed to a UHF electromagnetic field using a contact source in the physiotherapeutic mode at 1.2-1.5 W/cm^2 power for 1 to 5 min, depending on tumor activity. The period of subsequent cryodestruction of irradiated hemangioma was 1 to 3 min. Hemangiomas up to 1 cm thick were irradiated with a Luch-2 device, those thicker than 1 cm with a Pilot device. If the wavelength and attenuation coefficient are known, the depth of freezing can be estimated, which, with the above sources, was 1.3-3.7 cm. The procedure was repeated after 25-30 days, if necessary. The rate of ground waves was measured before exposure and after thawing in the

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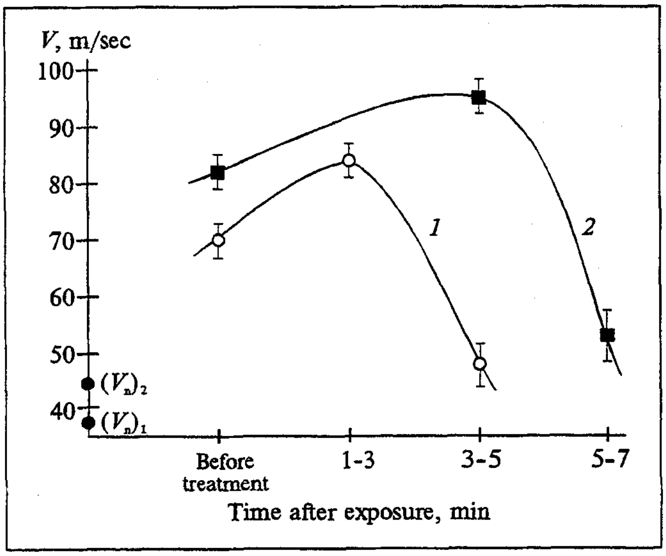

Fig. 1. Variation in rate of propagation of ground waves after cryotherapy in squamous (*1*) and cavernous (*2*) hemangiomas. The norm (V_n): rate in intact skin around hemangiomas for squamous $(V_n)_1$ and cavernous $(V_n)_2$ tumors.

same sites of the skin. The treatment was administered on an outpatient basis in the Department for Cryotherapy of Vascular Tumors, N. F. Filatov Pediatric Municipal Clinical Hospital.

A total of 296 children aged 1 month to 3 years were followed up. The localization of hemangiomas varied: face, neck, body, arms, and legs. Hemangiomas were classified in accordance with the characteristics defined previously [9].

Simple red or bluish-purple hemangiomas are localized superficially, with clear-cut borders, involve the skin and several millimeters of subcutaneous fat, and disseminate mainly to the sides. The surface of such hemangiomas is smooth, more rarely uneven, and sometimes protrudes above the skin. The shape and size vary from a few spots to extensive areas of different shape.

Cavernous hemangiomas are localized deep within the derma and consist of a conglomeration of

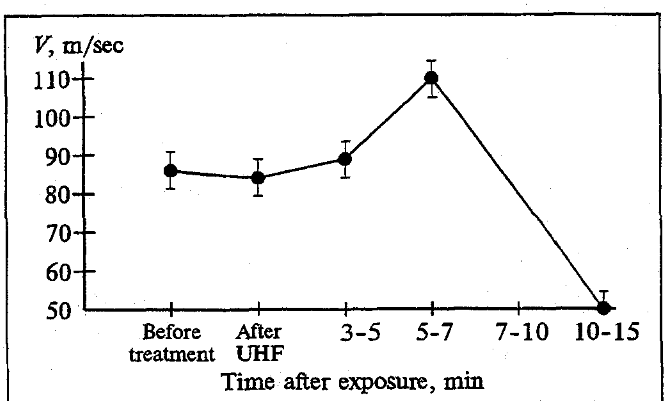

Fig. 2. Variation in the velocity of acoustic waves in cavernous hemangiomas after UHF–cryoexposure. V_n=46 m/sec.

cavities, presenting as local nodular formations from cherry to violet in color, of different size and soft consistency. Hemangiomas are frequently lobular or bumpy; when pressed, they contract and turn pale (because of blood outflow), and they grow larger and become denser during crying and coughing.

RESULTS

Measurements of the rate of propagation of acoustic waves in hemangiomas of different types showed that this parameter varies during treatment by different methods.

Cryotherapy.

This method was used in the treatment of children with cavernous hemangiomas with the subcutaneous part poorly expressed or as a first stage of treatment (for example, before sclerosing therapy or surgical treatment). Simple hemangiomas were always treated by this method. Changes in the mechanical characteristics before and after cryodestruction are presented in Table 1. No measurements are possible in cavernous hemangiomas 3-5 min after freezing because the tissue becomes very rigid. The process of superficial thawing was fixed at the moment when ground waves were able to propagate in the tissue and, hence, measurements became possible, this corresponding to the first readout on the digit counter.

A common tendency was observed in the behavior of the studied hemangiomas. The curves reflecting the relationship between the rate and duration of cryoexposure on Fig. 1 are similar, but the numerical parameters of the curves vary: the rates are higher in cavernous hemangiomas. Two stages of the process may be distinguished in both cases. Stage one: a drastic increase of the rate during tissue freezing and the "formation of an icy ridge". The maximal values of the rate are undetectable during this stage, because angiomatous tissue transforms into the "vitreous state" and the device cannot record the data. The second stage is thawing of tissue when ground waves begin to propagate in it.

The interval from freezing to thawing is different in different hemangiomas: 3 min on average for simple hemangiomas and 5 min for cavernous ones. This is in line with published data about a slower thawing of cavernous tumors [7].

The rate is 12±3 m/sec increased after the beginning of thawing in both types of hemangiomas. Note that the process of complete thawing leads to such a "softening" of tumor tissue that the rate in the angioma becomes compatible with that in intact skin. This was observed in angiomas

Table 1. Rate of Propagation of Acoustic Ground Waves V (m/sec) in Different Types of Hemangiomas before and after Cryodestruction ($p<0.05$)

Type of hemangioma	Rate before exposure			Rate after cryodestruction					
	intact skin V_n	angioma V_p	V_p/V_n	1-3 min		3-5 min		5-7 min	
				V_p	V_p/V_n	V_p	V_p/V_n	V_p	V_p/V_n
Squamous	39±2	65±4	1.66	78	2	39	1		
Cavernous	42±2	77±5	1.57			89	2.1	43	1.02

Table 2. Rate of Propagation of Acoustic Ground Waves V (m/sec) in Cavernous Hemangiomas after UHF Exposure Followed by Cryodestruction

After UHF		After cryodestruction							
		3-5 min		5-7 min		7-10 min		15 min	
V_p	V_p/V_n	V_p	V_p/V_n	V_p	V_p/V_n	V_p	V_p/V_n	V_p	V_p/V_n
85±5	1.84	90±6	1.95	95±5	2.06	112±6	2.43	50±4	1.09

Note. Rate before exposure: intact skin V_n=46 m/sec, angioma V_p=87 m/sec, V_p/V_n=1.89.

of both types: V_p/V_n=1, where V_p is the rate in the focus of pathology and V_n the rate in normal skin. The duration of this process is the same: about 2 min.

UHF-cryoexposure.

This method was used in the treatment of patients with cavernous hemangiomas with a well-expressed subcutaneous part. The findings permitted us to formulate regularities in the changes of mechanical properties of the tumor during combined UHF-cryoexposure. Numerical values of the parameters are presented in Table 2 and Fig. 2. Preliminary UHF exposure leads to a negligible reduction of the rate. The main action in UHF exposure is exerted on the dipolar structures, that is, chiefly on the water [3]. Polar molecules are stimulated under the effect of the UHF field. The frequency of the intrinsic fluctuations of water molecules is within the UHF range. Resonance phenomena develop. Changes in the hydration zone are possible, as well as ruptures of intermolecular bonds. All this destabilizes the structure of water, but poorly manifests itself in macroscopic biomechanical parameters [1].

The rate starts to increase after cryoexposure and increases by more than 25 m/sec after 7-10 min, with V_p/V_n=2.4. After 10 min of thawing the rate drops by more than 60 m/sec in 3 min. Thirteen to fifteen min after thawing is over, the rate drops to values comparable with those in intact skin: V_p/V_n=1.

Comparison of cryo- and UHF-cryoexposures.

Cavernous angiomas were exposed to cryo- and UHF-cryotherapy. Comparison of the two treatment modes showed that the mechanical properties of angiomatous tissue varied during these different exposures (Fig. 3).

Preexposure of tissue to UHF radiation leads to the formation of a more compact structure during subsequent cryoexposure. This was proved by the rate of ground wave propagation in the entire interval of follow-up. The difference between the maximal and initial rates was 12 m/sec for cryotherapy and 25 m/sec for UHF-cryotherapy. The times of the maximal rises in the velocity varied as well: 3-5 min for cryo- and 7-10 min for UHF-cryotherapy.

The rates fell after complete thawing: by 45 m/sec for cryotherapy and by 65 m/sec for UHF-cryotherapy. This quantitative comparison indicates

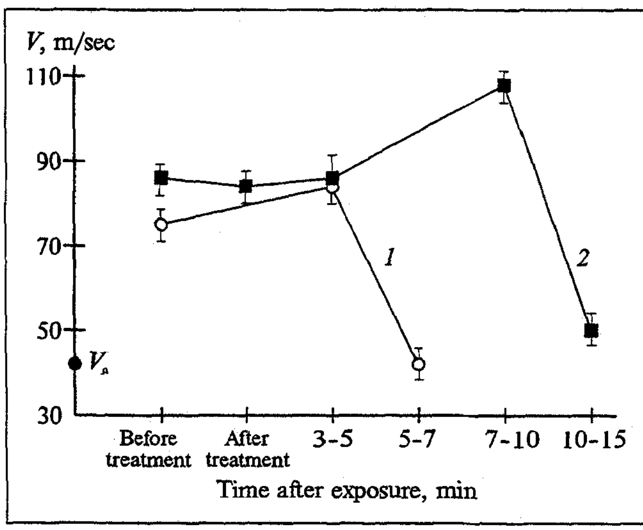

Fig. 3. Variation in the velocity of ground waves in cavernous hemangiomas after cryotherapy (*1*) and UHF-cryotherapy (*2*).

that preexposure of the area to be frozen to UHF microwaves enhances the cryogenic effect. The $\Delta V = V_{max} - V_n$ value, where V_{max} is the maximal rate, may be selected as the quantitative criterion of treatment efficacy. The greater the ΔV difference, the higher the effect of the studied factors on hemangioma tissue.

The use of the above-described methods of treating hemangiomas and their assessment by biomechanical parameters helped appreciably limit the use of surgery. Before these methods were introduced, surgical treatment was recommended to all (100%) patients, whereas since their introduction only 7% of patients have been recommended for surgery.

Hence, the results yield criteria for the choice of treatment and for objective assessment of treatment efficacy in children with hemangiomas.

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