patients on days 4-5 after surgery to assess the specific features of reparative regeneration processes. The resected ovarian sites were smooth in 4 patients; adhesion processes were detected in 2. Uterine tubes were clear in all patients. No intra- or postoperative complications were recorded.

The experimental and clinical findings attest to the efficacy of fibrin glue in ovarian reconstruction; this method helps reduce the incidence of postoperative adhesions.

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Measurements of Mechanical Parameters of the Skin in Patients with Lower Limb Varicosity

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Varicosity of the lower limbs is a highly prevalent disease [1], involving not only the vascular system, but the skin integument of the limbs as well, this being associated with venous stasis and microcirculatory disorders. The skin status is usually assessed visually and by palpation. Attention is paid to the skin color, elasticity, and the presence of edema of trophic disorders. However, the clinical methods used for this purpose seem to be subjected and not accurate enough. The importance of an objective characterization of the lower limb skin integument in patients with varicosity is evident, for it permits an adequate assessment of the disease pattern and severity and helps define the treatment policy.

Therefore, the development of accurate methods for the assessment of the skin status is a pressing problem that may be solved when a method is worked out that will yield objective quantitative information about the physical characteristics of the skin.

Measurements of the mechanical parameters of the skin may be used for this purpose. The authors have previously [2, 3] described a method for the assessment of these characteristics that is based on the use of the surface acoustic waves. The method is implemented using an ACA acoustic analyzer for soft tissues. This device has been widely used in medical practice of late: it is used in dermatology for the diagnosis of various skin diseases [4], in cosmetology to define skin type [5, 6], and in surgery to detect the tissues changed by cicatrization.

The aim of the present study was to reveal the diagnostic potentialities of this method in patients with diseases of the lower limb venous system and, specifically, to try to use it to assess the degree of venous insufficiency and the severity of local skin involvement, to detect acute inflammatory changes in the major veins, and to assess the extent of these inflammations.

The ACA apparatus permits measurement of the rate of propagation of surface acoustic waves in the skin; When this rate is known, it is possible to

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calculate, using the appropriate formulas, such viscoelastic characteristics as the shift module and the mathematically related Young's modulus of elasticity. The block diagram of the apparatus (Fig. 1) includes the acoustic pulse generator that transmits the signal to the emission piezoelectrictransducer (EPT) and the computer. Skin contacts are implemented by test probes situated at the tips of the piezoelectric transducers.

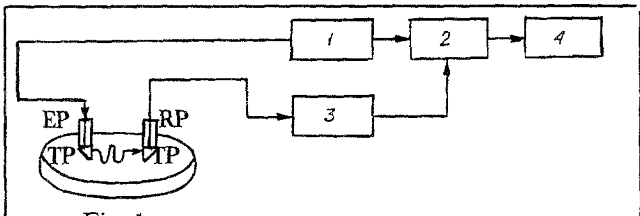

Fig. 1

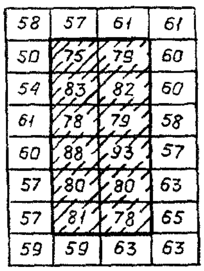

Fig. 2

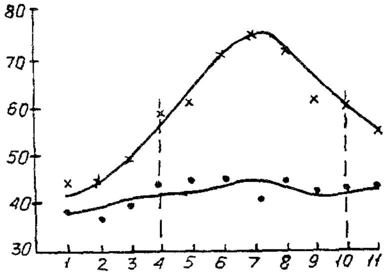

Fig. 3

Fig. 1. ACA block diagram: 1) acoustic pulse generator, 2) computer, 3) emission piezoelectrictransducer, 4) receiving piezoelectrictransducer, 5) test probes, 6) object of investigation.

Fig. 2. Rates of surface acoustic wave propagation in scanning of the skin in the pigmentation focus (shown by a bold line) and of apparently intact skin in a patient referred to group 2.

Fig. 3. Rates of surface acoustic wave propagation in the skin of patients with acute ascending thrombophlebitis: a) skin above inflamed vein, b) skin outside the focus of inflammation (1.5-2 cm from the inflamed vein); the broken line shows the boundaries of vein nonuniformity.

The distance *l* between the probes is fixed. An acoustic pulse is evoked in the thin surface layer of the skin, as a result of the flexural vibrations of the EPT, and an acoustic surface wave is propagated. It is received by the RPT and enters the computer from it; the computer estimates the time (*t*) of pulse delay in relation to the time of its emission from the EPT. The rate of surface wave propagation in the skin is estimated from parameters *l* and *t* according to the formula: $v = l/t$. The rate obtained is displayed at once on the digital indicator. The ACA is compact, weighs only 400 g, is self-powered, is simple to handle and easily readied for operation, and presents the experimental data instantaneously.

MATERIAL AND METHODS

Thirty female patients aged 35 to 50 with varicosity of the lower limbs were examined. The patients were divided into three groups in accordance with their clinical status: group 1 (10 patients) - lower limb varicosity without apparent signs of venous stasis; group 2 (10 patients) - varicose condition with signs of venous stasis, though without marked edema of the involved limb (the patients complained of a sense of heaviness in the limbs when standing or walking); group 3 (10 patients) - marked venous stasis with lower limb edema and dark cyanotic pigmentation of the skin.

Besides these, six patients with signs of thrombophlebitis of the great femoral subcutaneous vein were examined.

Ten women aged 35 to 50 without vascular diseases of the limbs made up the control group.

The patients were positioned horizontally for the examination. A net was drawn on the skin site intended for the examination; the cell area was equal to the ares of the transducer making contact with the skin. The measurements of the rate were carried out at points (cell centers) situated 1.5 cm apart. The transducer was positioned strictly perpendicular to the skin of the examined site. The net encompassed the focus of lesions and the adjacent apparently intact skin. When inflammatory processes in the venous bed were examined, the measurements were carried out along the protruding inflamed vein and at "quiet" skin sites at a distance of 1.5-2 cm from the vein.

The rate was measured three times at each point, after which the mean values for each skin sites were obtained. The error in measurements of the rate at one and the same site was not more ±2 m/sec. Mechanical anisotropy being a characteristic feature of the skin, measurements of the rate were carried out in one direction.

RESULTS

The ACA apparatus was used to measure the rate of surface acoustic wave propagation in the skin of the focus of involvement (V_f), in the apparently intact skin adjacent to this focus (V_i), and in the skin of the control subjects (V_c). The mean values are presented in Table 1.

The rates were found to differ both within the groups. The rates had a tendency to increase as the disease severity increased, being the lowest in group 1

TABLE 1. Rates of Acoustic Wave Propagation (Mean Values) in Patients with Varicosity of Varying Severity

Disease severity	Rate in pigmenta focus Vf (m/sec)	Rate in apparentl intact skin Vi (m/sec)	Difference in the rates dV = Vf-Vi	Rates ratio, %
Group 1	64±4	58±4	6	110
Group 2	84±6	60±4	24	140
Group 3	110±7	64±5	46	172

patients and the highest in group 3. This indicates that the status of the skin integument outside the focus of involvement differs in its mechanical parameters in patients with various degrees of severity of varicose involvement. It is noteworthy that parameter V in group 1 differed little from the V_c value in the control patients, being 55±3 m/s.

The V_f rate in skin sites with marked changes (edemas, infiltration, induration) was higher than the V_i value in apparently intact skin sites in all cases. This fact is not directly related to the severity of the venous insufficiency, although there is a certain correlation between the parameters. The V_f parameter increases much more intensively as the disease augments in severity than does the V_i parameter. The differences between the V_f values in various groups and the V_c value in the controls were as follows: 120 in group 1, 153 in group 2, and 200% in group 3.

Figure 2 presents the results of skin scanning in patient U., who was referred to group 2 by the clinical data. The values of the surface acoustic wave propagation rate at sites of marked skin changes in the central part of the ankle (shown by a bold line on the figure) and in apparently intact skin sites around this area are shown in the net cells. The figure demonstrates that the rate of wave propagation is higher at all sites of the focus of involvement than in the adjacent apparently intact skin.

On the basis of these data, one can choose different parameters for the diagnosis. For example, 1) wave propagation rate in apparently intact skin (V_i), 2) the rate in the focus of involvement (V_f), 3) the ratio of difference between the rates at involved skin sites and in apparently intact skin (V_f/V_i or $V = V_f - V_i$), or 4) the ratio or difference between the rates in the focus of changes and in the control group (V_f/V_c or $V_1 = V_f - V_c$).

The parameters V_f and V_i not only reflect the skin status at various sites, but depend as well on the individual characteristics of the patient, such as body weight, height, subcutaneous fat thickness, and general status. Parametr V_0 is a mean value for the control group that does not reflect any individual features. That is why we consider the V_f/V_0 ratio to be a more objective characteristic. This parametr varies in different clinical groups. This difference from the norm proper constitute for groups 1, 2 and 3 and 110, 140, 170%, respectively.

This apparatus was found effective for the assessment of changes in the venous bed in thrombophlebitis. Figure 3 shows the results of scanning the skin above the greater subcutaneuos femoral vein and along it in inflammation in patient T. Clinically the vein is thickened, the temperature of the skin above the vein is elevated, the skin reddened along the entire vein, local edema is seen, and the site is painful, particularly during palpation. The rate values measured in scanning along the inflamed vein were considerably higher than the values measured along the scanning lines in the adjacent skin. The difference from the normal values constituted 136% in this example. Note that the rates along the vein vary. Two sites (their borders are shown by a broken line) may be distinguished on Fig. 3 that point to nonuniformity of the inflamed vein. A clot in the vein may be responsible for it.

Examinations of convalescents after thrombophlebitis have shown virtually the same values along all the scanning lines.

These findings may help specify the disease diagnosis, for they provide additional information on various manifestations of lower limb varicosity, and help develop the correct treatment policy.

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