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A New Instrument for the Evaluation of Tissue Tonicity in Lymphoedema

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Summary

An instrument which measures the resistance of the tissues to compression has been used to assess the effectiveness of a therapy for long term lymphoedema. In this preliminary study, all cases of long standing lymphodema showed an increased resistance of the affected tissue to compression. Following an average of 30 months' Venalot treatment the resistance of the fibrotic tissues was restored to normal levels. It is believed that this way of assessing the state of the tissues and the value of therapy is a more accurate representation of the actual situation and should be used in preference to measurement of the circumference or plethysmography.

Introduction

In the course of progressive high protein oedema the subcutaneous tissues gradually become fibro-sclerotic, partly because of the high protein concentration of the stagnant oedema fluid, partly because of repeated attacks of infections. This may lead to a decrease of joint movements of the involved extremity and to subjective complaints such as bursting pains, feelings of heaviness. From the standpoint of therapy it is as important to stop or prevent the fibrosis or fibrosclerosis as it is to obtain a reduction of the circumference of the extremity. However continuing fibrosis alone may result in a reduction of the circumference of the limb thus simulating a clinical improvement.

In order to obtain a more accurate objective assessment of the state of the lymphoedematous limb and the benefit of therapy, a tissue tonometer was designed. This papier describes this newv instrument and reports on some of the preliminary research.

Methods

Description of the Instrument

The principal mechanism of function involves the testing of the resistance of the tissue to compression as derived from the use of a similar instrument in opthalmology. Figure 1 illustrates the instrument. The body is made of perspex while the foot plate, column and scale are of brass alloy. All parts can be sterilised.

The central column (plunger) has a base surface area of 28.5 mm^2, while the foot plate has a area of 1785 mm^2. From one to three brass alloy weights can be added to the central column. Each weight is of 60 gm. The distance of depression of the central column into the tissue is measured on the graduated scale. Each mm of compression is represented by the movement of the pointer over one whole division (5 subdivisions).

Method of Measurement

The instrument is placed on the affected arm or leg and allowed to stand free. The patient supports the extremity in a horizontal position on a table, and is told to allow the muscles to relax. The central column is placed between ulna and radius (Fig. 2). The first weight is then added to the central column and the distance of compression immediately recorded. The second and

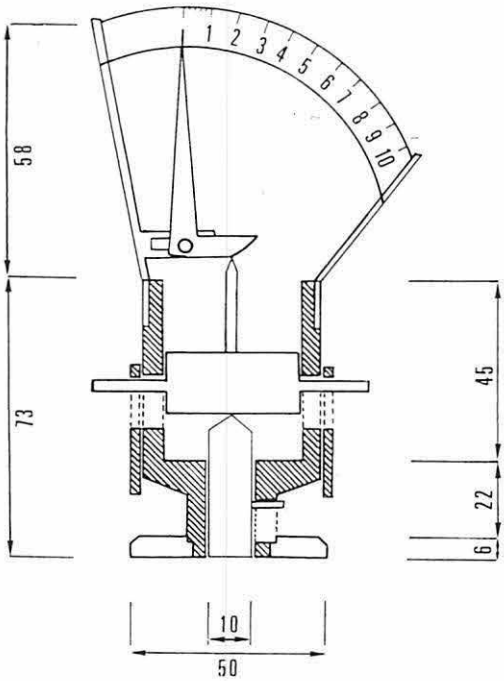

Fig. 1 All measurements are in millimeters. The hatched areas represent perspex while the clear areas brass alloy.

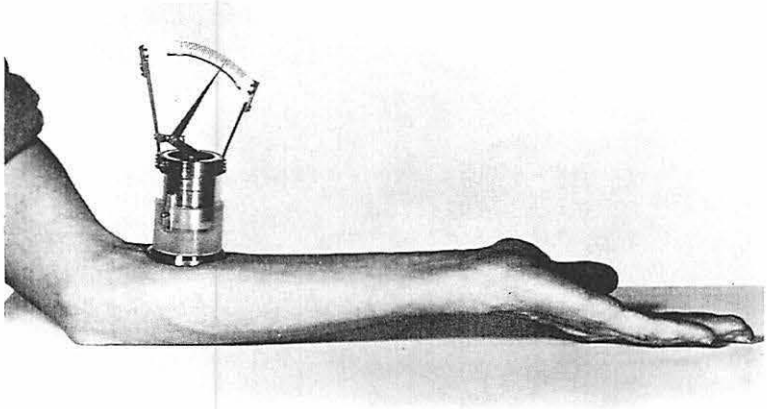

Fig. 2 Showing positioning of instrument on the fore-arm. It is placed such that the central column comes to be between the ulna and radius.

third weight are added individually and the respective depressions recorded. A similar procedure is performed on the normal limb, taking care to ensure that it is placed at an equivalent position. At each occasion 3 measurements were taken and the average used for the final calculation.

For the preliminary trials of the resistances of tissues to compression that of 24 normal forearms were measured. Twelve cases of long standing primary and secondary lymphoedema were also tested. The average duration of this lymphoedema was 8.3 years. All the limbs examined in this group had well developed fibrosis which was demonstrable clinically. In addition 4 cases of long standing lymphoedema (average duration 7.5 years) who had been given two tablets of Venalot® (each containing 15 mg coumarin and 90 mg troxerutin – Schaper & Brümmer, Western Germany) each A.M. for an average of 30 months have been tested. This drug has often been reported by patients to reduce the feeling of heaviness, tension and "stone like" appearance of the affected limb. Previously these were impossible to assess objectively; the tissue tonometer, we believe now makes this more possible.

Results

At present we have only a very small sample, however a statistical analysis shows some very interesting results.

A comparison of the resistance to compression between the normal and lymphoedematous tissues showed significant differences at each of the weight levels tested. In each case the tissues of long standing lymphoedema were significantly more resistant to compression. For the 60 gm weight this was $p < 0.001$, t test, 34 d.f.: for the 120 gm combination this was $p < 0.001$, t test, 34 d.f. and for the 180 gm combination was $0.001 < p < 0.01$, t test, 34 d.f.

A comparison of the resistance to compression of normal tissues with those of long standing fibrotic lymphoedema which were treated with Venalot showed no significant difference for any of the weight levels tested (Fig. 3).

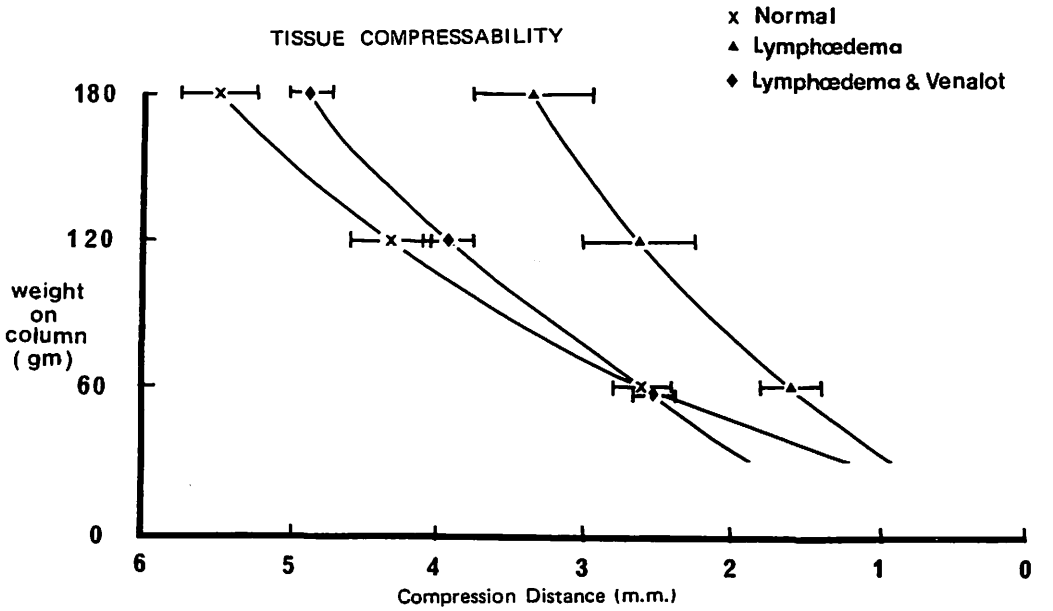

Fig. 3 Graph of the resistance of normal and lymphoedematous tissues to compression. Standard error of the mean of each point of observation is shown.

Discussion

It is well known that as lymphoedema progresses, the tissues slowly become fibrotic or fibrosclerotic through overgrowth of the interstitial connective tissue (2). In this way the initial soft stage of lymphoedema is transformed into the hard brawny late stage form (1). As a consequence the tissue becomes more resistant to compression when compared to a normal limb.

There are a great variety of both conservative (4) and surgical (1) therapies for the removal of lymphoedema. The eventual success of such a therapy is determined most often by measuring the circumference differences between the normal and affected limb or by plethysmography. It is now becoming evident that such measurements should be treated with care since often following the development of fibrotic tissue, the affected limb may become smaller albeit harder. This could give a false indication of the value of the therapy.

For this reason the tissue tonometer was designed. Essentially it measures the resistance of the tissue in compression. Thus it will enable the clinician to distinguish between the limb which is becoming smaller, not through the result of the therapy but because of continuing fibrotic development, and that which is showing a real improvement with removal of the fibrotic tissue and a restoration of the normal resistance to compression. The results of this report show a very significant difference between the resistance to compression of the normal tissues and those with long standing lymphoedema. This difference is particularly evident at the heavier weight levels (Fig. 2). A comparison of the normal tissue compressibility with that of the lymphoedematous tissue of the patients treated with Venalot showed no significant difference. This means that the tissues had been restored to their normal softness. A rather interesting point arises here. Of the 4 Venalot treated patients only two of them had what we called an objective improvement (a reduction in circumference of 2 cm of more over the period of observation). All however showed a tissue compressibility which was not distinguishable from that of their normal limb. This result certainly fits in better with the patients' reports. All patients in this group in fact claimed subjective improvements such as a reduced feeling of heaviness of the affected limb, less busting pains and less numbness, which all tie in well with the restoration of normal tissues compressibility.

How do these results fit in with what is known of the progressive histopathological state of lymphoedema and its conservative therapy with Venalot? The progressive connective tissue overgrowth accompanying lymphoedema (2) which replaces the proteinacious fluid with hard tissue certainly results in a loss of the tissue elasticity. Accompanying this is a high degree of fibroblastic activity resulting in fibrination and subsequent closure of lymph and vascular pathways. *Olszewski* (3) has observed the growth of compact collagen bundles in close approximation to these vessels, thus lymphatic function is further impaired. The continual presence of high protein levels in the tissues is an ideal growth medium for fibroblastic cells resulting in further fibrosis. A vicious circle thus begins.

If left untreated the tissues become more and more resistant to compression. The rate of formation or destruction of the existing fibrotic tissue is determined by the balance between collagen formation and lysis. The available evidence suggests that the reason for the restoration of tissue compressibility following Venalot treatment is that it can turn this balance in favour of lysis. Theoretically once the fibrotic tissue is gradually removed the limb will become softer. This, we believe, is responsible for the subjective improvements which the patients report, while objectively most often no improvement was demonstrable.

It would now seem that with the advent of this tissue tonometer an earlier objective measurement can be made to confirm the patients' subjective claims (4). The results of tonometry certainly seem to fit in well with the subjective improvements claimed by the patients, and would seem to give a more accurate representation of the value of the therapy at an earlier time than previously possible. Measurements of tissue tonometry also seem to be more reliable than a similar

measurement of the state of the affected limb by circumference or plethysmography. Further tests are being performed on larger sample groups.

Addendum: The instrument was designed by L. Deak.

References

1 *Clodius, L.:* Secondary Arm Lymphoedema. In "Lymphoedema". Ed. L. Clodius. Stuttgart: Thieme 1976
2 *Drinker, C.K., M.E. Field, J. Homans:* The experimental production of edema and elephantiasis as a result of a lymphatic obstruction. American Journal of Physiology, 108 (1934) 509
3 *Olszewski, W.:* On the pathomechanism of experimental lymphoedema. Polski przeg. chirurgie 9 (1973) 926
4 *Piller, N.B., L. Clodius:* The clinical effectiveness of Venalot on primary and secondary lymphoedema. British Medical Journal – submitted for publication 1976
5 *Stillwell, G.K.:* Treatment of postmastectomy lymphoedema. Modern Treatment, 6 (1969) 396

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On Radioactive Labelling of the Lymph Drainage Regions of the Pelvis

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Summary

The introduction of radioisotopes in the surgical management of cervical carcinoma at our clinic in 1970 constituted a major advance in this respect. Prior to surgery the lymphatic tissue of the pelvic region is labelled by subcutaneous applications of radioisotopes. Our experience shows that the body's kinetics encourage the deposition of the radionucleide and thus visualization even of the groups of lymph nodes located in the deeper layers of the pelvic region. This method allows virtually complete lymphonodectomy with resultant improvement of cure rates.

The possibility of carcinomatous spread to regional lymph nodes should be taken into consideration in all clinical stages of uterine cervix carcinoma (1, 2). Authors who perform compulsory lymphonodectomies report an incidence of gland- positive cases which is 60–100% higher than the one found by authors performing optional removal of lymphatic tissue with cancer metastases (3). This along with other statistically significant evidence indicating that obligatory lymphonodectomy can improve the 5 year cure rate (4), makes the conventional radical operation with obligatory removal of lymphatic tissue the procedure of choice for treating operable cases of carcinoma of the cervix. In order to achieve as complete as possible a removal of the regional lymphatic tissue, the *Radioisotope Radical Operation* was introduced in 1970 and became part of the therapy program for treatment of uterine cervical carcinoma (5). In this technique the fact that lymphoreticular tissue will store radioactive colloids following interstitial administration