Lymphology 18 (1985) 192-194

A TISSUE TONOMETER FOR USE IN THE FIELD

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ABSTRACT

A robust tissue tonometer is described which is suitable for use in the field.

The tissue tonometer was introduced by Clodius and Piller (1-3) as a device to measure the "tone" of the tissue. In effect, it quantitates the clinician's finger. The tonometer not only measures the amount of "pitting edema" but also detects increased tissue fluid before edema is actually clinically evident. Such numerical information provides hard data for use in the long-term monitoring of a patient who is liable to develop lymphedema, e.g. after mastectomy (3,4), and for the evaluation of therapy. Indeed, we have repeatedly found that tonometer values improve during a successful treatment regimen, long before the limb volume can be detected as being smaller or the circumference less (2,5,6). This is partly because the [Standard Errors]/[Mean Difference] are usually less for tonometric estimations than those of limb volume or circumference, and partly because the tonometer measures the tissue tension, a reduction in which must precede a reduction in the limb volume.

What is the tissue tension which the tonometer measures? Unfortunately this is not a single parameter. The "tone" is measured in arbitrary units. The values increase as the tissue becomes looser and more easily distorted. They are inversely proportional to the tissue hydrostatic pressure (i.e. the pressure of the fluid in the tissue channels); they increase with increased hydraulic conductivity of the tissue channels; they are inversely proportional to the solid tissue pressure exerted by all the solid tissue elements (including, most importantly, fibrous tissue).

The readings, however, have to be interpreted with care. A limb tightly filled with edema is almost incompressible; one less filled is more compressible (and the more edema it has earlier, the more it can be compressed when this fluid has gone); one with extensive fibrosis again has low compressibility. A knowledge of the progress of the edema, and what treatment has been provided are required to make these distinctions. Fortunately, such information is consistently available for the individual patient. Thus the tonometer is a useful, simple, non-invasive monitoring device.

The original tonometer (1,2) though an excellent and sensitive device, had to be handled with care, was relatively easily damaged, and was thus generally unsuitable to conditions in the field, e.g. in villages in India. The instrument described here is designed to be more robust. While it is calibrated in mm, rather than 0.1 mm, in practice measurements are only reproducible to the nearest mm. The only part of the instrument which can be broken or bent is the indicator, which can easily be replaced or readjusted to zero after standing the instrument on a flat surface. Finally, if the tonometer becomes filled with mud or dust, the debris can readily be washed out.

The construction and dimensions are shown in Fig. 1. The material used is brass. The only adjustment necessary before use is to place the instrument on a flat surface and bend the indicator until it reads zero.

The tonometer is held vertically and

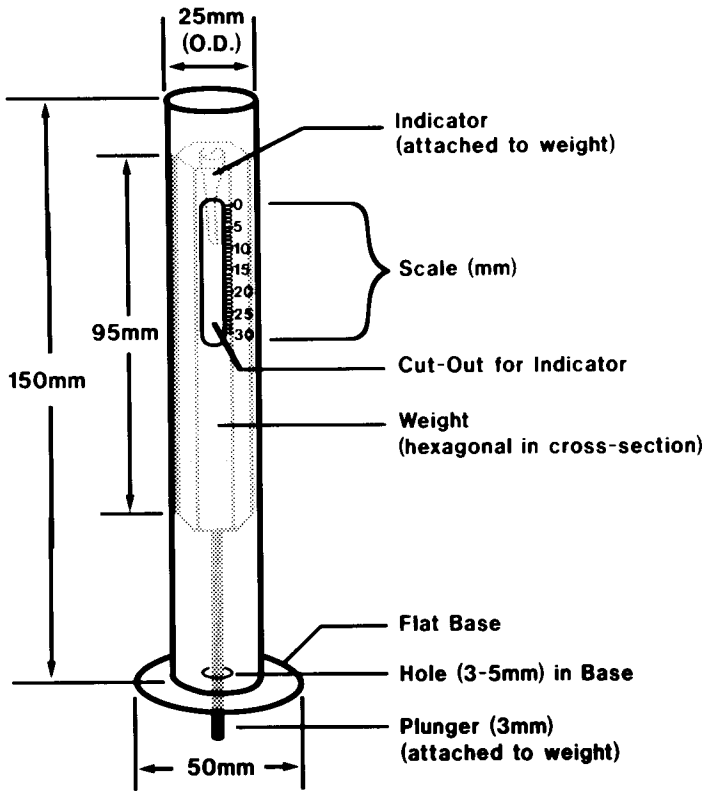

Fig. 1: A scale drawing of the tonometer, showing the essential dimensions. The casing (25 mm outside diameter, 23 mm inside diameter, and 150 mm high) is made of brass, 1 mm thick, as is the flat base (50 mm diameter, 1 mm thick). The casing has a slot, 40 mm high and 6 mm wide, marked in mm graduations on one side (numbered at 9, 5, 10, 15, 20, 25 and 30 mm), through which projects the indicator. This is attached to the top of a brass weight by a screw. The weight is hexagonal in cross section (to allow free movement in the presence of dust), 22 mm at its greatest diameter and 90 mm long. To this is attached a brass plunger 3 mm in diameter and 50 mm long. Its end is flat, but with the edge bevelled for 0.5 mm centrally and vertically. The plunger passes through a 3.5 mm hole in the base, which rests on the skin. The indicator shows how deeply the plunger depresses the skin.

rested, at standardized positions, on the arm or leg. The skin on which the instrument is placed should be approximately horizontal. On the arm, the preferred sites of measurement are the anterior surface, at 10 cm distal and proximal to the elbow, with the arm supported by a table. On the leg preferred sites are on the posterior aspect, at 20 cm distal and proximal to the knee. Three measurements are taken at each site.

The results with this instrument are similar but not identical to those with the earlier models. On the other hand, variations, with time, are similar and consistency is the most important feature. Measurements are recorded in arbitrary units (which change as the applied pressure is altered -varying with changes in the force applied to the plunger, and inversely with its diameter). Provided the same instrument (or similar ones) is used for each measurement comparisons may be made in one patient at different time intervals or among

groups of patients.

Although these tonometers are not available commercially, I have a few extra samples that I am willing to send to interested readers willing to defray relevant costs. Alternatively, the specifications are provided to permit non-commercial self-construction (Fig. 1).

ACKNOWLEDGMENT:

I am grateful for the skillful assistance of Mr. T. MacKenzie, who made the instrument.

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