Dichromography—a Method for in vivo Quantitative Analysis of Certain Elements

Abstract. The method is based on absorption measurements of monochromatic x-rays. The radiation dose given to the patient is low, and thus the method is nondestructive. The physiological content of iodine in the human thyroid can be determined, as well as the distribution in the body of small amounts of roentgenological contrast substances.

A nondestructive method for the quantitative analysis of elements inside a living person would be of value for determining the function of organs in diagnostic and physiological studies. The use of monochromatic x-rays makes it possible to determine certain heavy elements as well as ensuring an optimum amount of contrast per dose given to the patient when producing radiographic images.

Any one element can be quantitatively determined according to the Beer law by measuring the attenuation of one monochromatic x-ray beam (*1*). Similarly, two elements can be analyzed with two monochromatic rays, provided that the ratios of the mass absorption coefficients of the elements are sufficiently different at the two wavelengths. To the first approximation the human body is composed of soft tissue, bone salt, and iodine (normally present in the thyroid or otherwise employed as a roentgenological contrast medium). If bone structures are avoided, two wavelengths are therefore sufficient for an in vivo analysis of the amount of iodine and soft tissue in a body section. Preferably the two wavelengths are chosen on each side of the absorption edge of iodine at 0.37 A (*2*).

The equipment comprises an x-ray tube for the production of monochromatic radiation through secondary emission, a system composed of two servo-controlled absorption wedges, a scintillator photomultiplier unit sensing the x-ray intensity, and an electronic feedback loop from the mutliplier to the two servomotors (*3*). One wedge is composed of material equivalent to soft tissue (for example, water); the other, of iodine. The two wedges are automatically kept in such a position that the intensities at the scintillator are constant. When the patient is placed in the beam, the two wedges are withdrawn a certain distance corresponding to the amount of soft tissue and iodine in the patient. Thus, the displacements of the two wedges are quantitative measures of the amounts of these substances. A scanning process is employed when producing images, showing the quantitative distribution.

At present the accuracy of the method is within ± 0.2 mg of iodine per square centimeter for static measurements and ± 0.5 mg/cm^2 when scanning is employed at a rate of 0.5 cm/sec and with a beam cross section of 0.25 cm^2. The accuracy is limited by statistical fluctuations of the number of quanta in the x-ray beam and by photomultiplier drift. Another error not included in the values given is caused by the presence of fat in the tissues. Fat has an absorption characteristic slightly different from that of the soft tissue wedge (water). Thus, 1 g of fat per square centimeter simulates the presence of 0.5 mg of iodine per square centimeter.

An additional advantage of the soft-tissue wedge is that the dose given to the patient is at a theoretical minimum. The beam is constantly attenuated so as to allow no more quanta to pass the patient than those necessary for the desired statistical accuracy. During a typical investigation of the thyroid, the dose becomes less than 1 mr.

The iodine distribution in a normal thyroid can be seen in Fig. 1. Each plotted curve represents the mean value of the ink recordings of two adjacent scanning lines. Deviations on the base level, representing the zero iodine values, are due to statistical fluctuations in the beam. It should be noted that no iodine, stable or radioactive, has been given to the patient before the investigation. The method is thus entirely different from that employed in radioiodine thyroid function tests.

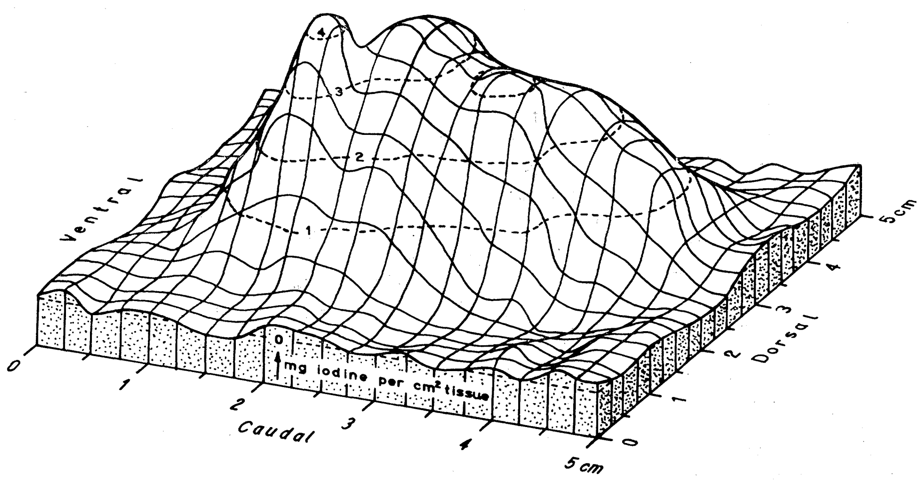

Fig. 1. Stereogram showing the distribution of iodine in a normal human thyroid. The peak concentration of 4 mg of I per square centimeter in the caudoventral part corresponds to the thyroid isthmus. The total amount of iodine in this thyroid was 23.5 mg. No iodine had been given to the patient prior to the determination.

The method has also been used for function tests of the liver, kidneys, and lungs, or of localized parts of these organs, in human beings and other animals, performed by studying the amount of iodine present in the organs after intravenous injections of contrast substances containing iodine (*4*). Circulation tests are also possible, as is the determination of the amount of blood in certain parts of the body.

Preliminary experiments indicate the possibility of measuring the amount of bone salt simultaneously with determination of the iodine and soft-tissue values by means of three selected wavelengths and three wedges (*5*).

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References and Notes

1. For a review of such methods, see A. Engström, in *Physical Techniques in Biological Research*, G. Oster and A. W. Pollister, Eds. (Academic Press, New York, 1956), vol. 3, p. 489.
2. B. Jacobson, *Acta Radiol.* 39, 437 (1953).
3. ——— and R. S. Mackay, in *Advances in Biological and Medical Physics*, J. H. Lawrence and C. A. Tobias, Eds. (Academic Press, New York, in press), vol. 6.
4. A report on these tests, written in cooperation with P. Edholm, is in preparation.
5. The method described has been developed during the last three years by means of financial support from Knut och Alice Wallenbergs Stiftelse and from Harald och Greta Jeanssons Stiftelse.

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Effect of Growth Hormone on Lipid Aldehydes

Abstract. Female rats at the body weight plateau which responded to 13 daily injections of 0.4 mg of growth hormone by greater weight gain per gram of food had a decreased concentration of lipid aldehydes in blood plasma, an increased concentration in liver, and no change in intestine, compared with control rats given isotonic saline.

The administration of growth hormone (GH) decreases the rate of turnover of plasma phospholipids in man (*1*) and increases the content and the rate of turnover of the phospholipids of the liver