

# RADIOIODINE UPTAKE BY THE THYROID GLAND

The thyroid gland produces a variety of amino acids all of which contain iodine. A small amount is released by the thyroid each day for use by the body's tissues but the bulk is stored in the gland. A very great part of the total amount of iodine in the human body is therefore contained in the thyroid. Each day the thyroid gland accumulates from the blood about that amount of iodine that is required to replace what it releases, incorporated in amino acids (thyroid hormones). If a small amount of radioactive iodine is administered to a patient whose thyroid function the physician wishes to study, it follows the same path as ordinary iodine taken in with food and water; that is, a part of the administered dose is accumulated by the gland, another part is excreted via the kidneys and a very small amount goes to other parts of the body. Determination of that fraction of a radioiodine dose which is taken up by the gland within a given time, therefore, allows the physician to gain some insight into the daily consumption of iodine by the gland and hence its daily production of thyroid hormones.

The two most important, although not most common, diseases of the thyroid are associated with either a higher than normal rate of hormone production (hyperthyroidism or thyrotoxicosis) or a lower than normal production (hypothyroidism or myxoedema). Consequently, a high radioiodine uptake by the gland is usually found in the former and a low uptake in the latter condition. There are, of course, various other means at the disposal of the physician to make a diagnosis of thyroid malfunction - e. g. observation of clinical signs and symptoms, determination of the basal metabolic rate and other tests - but the measurement of thyroid radioiodine uptake provides the most direct indication of abnormal hormone production, particularly if it is combined with other radioiodine tests such as determination of the concentration of hormonal radioiodine in the blood. The radioiodine uptake is also usually found to be high in the most common thyroid disorder, namely endemic goiter, where the gland is frequently greatly enlarged without increase in hormone production. Thus, the thyroid radioiodine uptake test is now one of the most widely practised medical applications of radioisotopes and, because of its practical value, is usually the first technique adopted by a newly established hospital isotope laboratory.

## Principle and Methods

The principle of uptake measurement is relatively simple. The amount of gamma-radiation given off by radioiodine which has been accumulated by the thyroid at a certain time after its administration to the patient is compared with the amount of gamma-radiation emitted by the total dose of radioiodine contained in a vessel known as the "standard". In the

ideal case, both measurements should be done under identical conditions, i. e. the relationship between the radiation detector on the one hand and the thyroid gland and the "standard" on the other hand should be the same. However, complete duplication of these conditions is impossible due to the complexity of the relationship of the thyroid gland to the neck tissues which surround it and because of individual differences in this relationship between one patient and another. Therefore, the main problem is to carry out the measurement in such a way as to reduce to a minimum the errors resulting from the differences in the relationship between the two sources and the detector and the effects of individual variations between patients.

Since the first measurements of thyroid radioiodine uptake were carried out nearly twenty years ago, many laboratories have had their own ideas on how the measurements should be made and have developed their own "house" methods. Nowadays, the techniques vary widely from one country to another and there does not appear to be a standard method which would be acceptable to all workers in this field. Consequently, it is difficult to compare the results obtained and their value is often doubtful. In fact, many laboratories have expressed doubt about the accuracy of their own results due to lack of suitable equipment with which their method could be calibrated.

In order to assist its Member States in the calibration and standardization of such measurements, the International Atomic Energy Agency has started a project under which a member of the Agency's scientific staff, who has specialized in this work, is about to begin a series of visits to different Member States at their request. Using as calibration equipment a dummy figure containing known amounts of "mock" radioactive iodine (i. e. a radioactive substance with radiation characteristics nearly identical to that of I-131 but with a much longer half-life), this expert will calibrate existing local apparatus for the measurements, calculate correction factors where appropriate and suggest - if necessary - a standardized method of measurement so as to ensure that the results obtained are comparable with those reached at medical institutions in other countries.

## Experts' Recommendations

Before embarking on this project, the Agency sought the advice of a number of well-known specialists\* in this field on a suitable method of measurement that could be accepted as a standard procedure.

\* The experts were: Dr. G.F. Barnaby (UK), Dr. R. Höfer (Austria), Dr. Wolfgang Horst (Federal Republic of Germany), Dr. L-G. Larsson (Sweden), Dr. D.A. Rose (USA), Dr. W.K. Sinclair (USA), Dr. Ir. Chr. Sybesma (Netherlands), Dr. N.G. Trott (UK) and Dr. M. Tubiana (France). From the Agency's Secretariat, Dr. H. Vetter served as moderator and Dr. G. Gómez-Crespo as secretary.

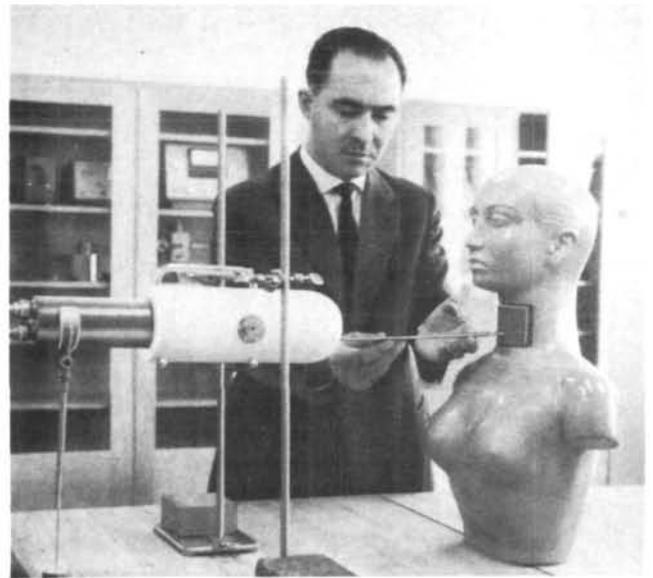
The experts met in Vienna in November 1960 and drew up recommendations primarily with the object of assisting the Agency in carrying out its calibration project. They also expressed the hope that these recommendations would be useful to both advanced and developing countries since they would help in assessing the suitability of existing equipment and procedures and provide a guide to newcomers in the field on at least one good method of measuring thyroid uptake. The experts were, however, aware that several other methods, if carefully employed, could produce equally satisfactory results. Their object in recommending a particular procedure was to establish a relatively simple but reasonably accurate standard method which could be used even under rather primitive conditions. If inter-comparison of results could be facilitated by the adoption of such a standard method, there would be greater confidence in the published results and a sounder basis would be found for comparing geographical variations in thyroid function. The recommendations which are being published in specialized scientific journals are briefly summarized below.

To start with, it is stated that as a general principle the amount of radioiodine administered to the patient should not be larger than necessary, particularly with children. With good equipment and standard procedures, not more than ten microcuries of iodine-131 need be given. Higher doses, however, may be necessary in special circumstances.

The amount of radioiodine used in the "standard" should be the same as the amount given to the patient, and the volume of the "standard" should be comparable to the volume of an average-sized thyroid gland. The use of a neck phantom is also recommended, in order to simulate as closely as possible the effects due to the presence of neck tissues, other than the thyroid gland, which are within the detector's field of vision. This phantom should be a plastic cylinder of 15 cm in diameter and 15 cm in height, with a hole to accept the standard vessel. As for the detector, the use of a scintillation counter is recommended but it is stated that a Geiger-Mueller counter can also be used under certain conditions.

The recommendations on operational procedure relate to the optimum distance between the detector and the source, the optimum time, the position of the patient, the effects of background and scattered radiation, and counting statistics. It is pointed out that the optimum distance between the source and the counter will depend on several variable factors, but in most cases a distance of between 20 and 30 cm would appear satisfactory, provided it is kept exactly the same in both sets of measurements. The thyroid uptake should preferably be determined after 24 hours and in any case not within two hours of the administration of the tracer dose.

In order to minimize the contribution from background radiation and from extrathyroidal neck radioactivity the group laid down detailed specifications for shielding and collimation of the detector. Maximum values for count rates, expressed as a percentage of

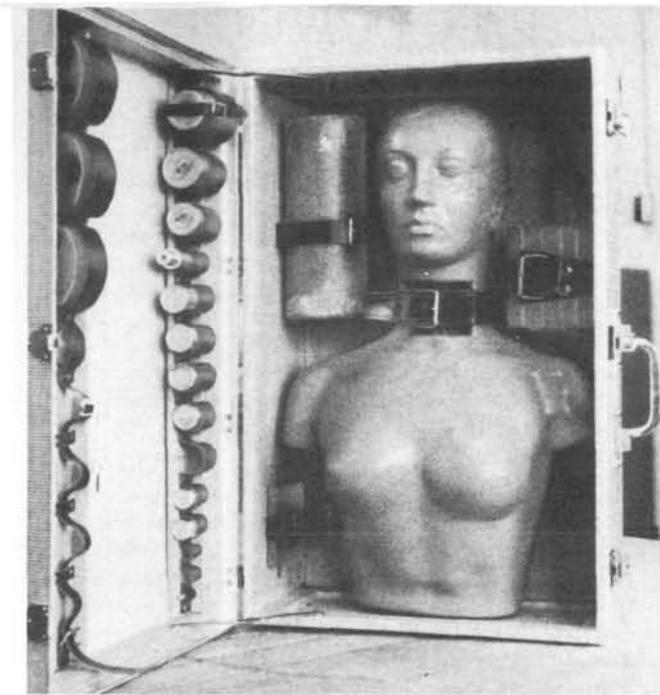


Dr. Gomez-Crespo, a member of the Agency's scientific staff, who will visit a number of countries for the standardization of thyroid uptake measurements, measuring the distance between the mock thyroid of a dummy figure and the crystal of a scintillation detector

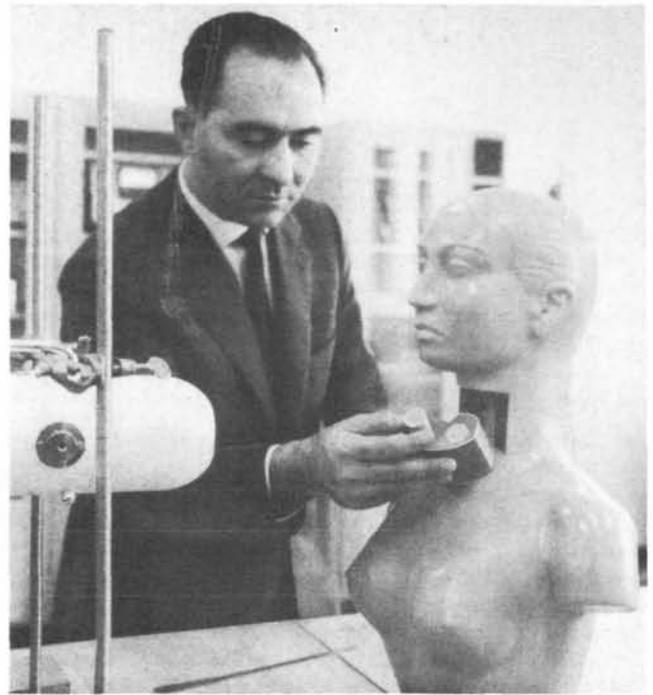
the maximum count rate along the central axis, are given for various points outside the field of vision of the detector. It was recommended that scattered radiation, i. e. all gamma-radiation from the source which does not directly reach the detector, should be excluded either by placing a lead filter of 1.5 mm thickness in front of the detector or by properly setting the electrical threshold.

## Calibration Equipment

The calibration equipment which the Agency's expert takes with him was put together in the Agency's laboratories in Vienna. Its principal features follow those first devised by the Medical Division of the Oak Ridge Institute of Nuclear Studies in the United States several years ago, with some important modifications. A dummy figure of the upper part of a human body was constructed using fiber glass, and the dummy was filled with a small amount of "mock" radioactive iodine in order to simulate "body background", i. e. the radiation which, under "live" conditions, is given off by that part of the administered dose of I-131 which, at the time of measurement, has neither been accumulated by the thyroid gland nor been excreted by the kidneys but is present in other parts of the body or in the circulating blood. In the place of the thyroid gland there is space left in the neck of the dummy figure to insert plastic containers. There are several such containers which vary in size to simulate the sizes of normal and enlarged thyroid glands and also vary with respect to the amount of "mock" iodine they contain so as to represent three different situations which might be observed in human subjects: normal, high and low



The dummy figure placed in a specially constructed suit-case in which it will be carried to different countries. The travelling test kit also includes interchangeable mock thyroids and a set of "standards"



Dr. Gomez-Crespo demonstrating the interchangeable mock thyroid in the dummy figure

radioiodine uptake. Further, there are a number of "standard" vessels of various sizes and shapes containing amounts of "mock" iodine representing the total dose administered to the "patient". Finally, a plastic neck phantom and various filters are included in the calibration set.

The actual amounts of "mock" iodine contained in the various models of the thyroid and in the various standard vessels were measured with great precision in the standardization section of the Agency's laboratory, so that the ratio between the activity of the "gland" and that of the "standard" is accurately known. This allows each laboratory to test the accuracy of their technique by carrying out an uptake measurement on the dummy figure. If their technique is satisfactory the results should correspond to the known ratio; if small differences are found, appropriate correction

factors can be calculated without modifying the technique substantially. If, however, the currently used method proves to be unsatisfactory, the expert will suggest the adoption of the standard method recommended by the group mentioned above.

It is expected that the expert will stay in each country for about one to two weeks, depending on the number of laboratories he is asked to visit. So far, nineteen countries have formally requested the Agency's services and several others have expressed interest. Visits of the expert will be arranged to groups of countries in a particular region of the world and the first tour has been scheduled for a small group of European countries to allow the expert to return to Vienna if experience should indicate the need for any modifications of the equipment to be done before countries outside Europe are visited.