Chapter 22

THYROID UPTAKE TEST

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Measurement of the uptake of the radioiodine by the thyroid gland was one of the earliest applications of the radioisotopes in medicine but in advanced countries it is now seldom carried out. There, the test is considered, more or less, of historical interest only. However, the situation is quite different in the developing countries, where it is still the most commonly performed in vivo nuclear medicine investigation. Not only that, but in many of the laboratories, it is the only test that is being carried out. Reasons for this are quite simple: the radioiodine is easy to obtain, has a convenient shelf life, the requisite instrument is simple and commonly available in a radioisotope laboratory. Moreover, the thyroid is still the largest single referral to a nuclear medicine department from the hospital and the laboratory finds the thyroid uptake test as the simplest to offer.

As far as its clinical utility goes, the reputation of the test is undeserved. Its information content is poor and it gives quite a hefty radiation exposure to the thyroid gland, if done with ^{131}I. Most of the times it provides much less information than the radiation dose that it delivers to the gland, which is in the order of 1.5 rads per μc in the thyroid.

The test has other serious limitations also because it is based on a series of assumptions. It assumes that rapid and high uptake signifies increased hormone production. This is not always true because iodine deficiency, enzyme defect and several other causes can also give a similar uptake pattern. Increased import of the raw material does not necessarily mean increased production.

The uptake of radioiodine by the thyroid gland is also altered by the iodine content of diet or drugs. American diet has a high iodine content because each slice of the white bread contains nearly 150 μg of iodine due to the bleaching process employed in the production of the bread. This carrier content of iodine reduces the uptake so much, that the normal American uptakes are usually three to four times lower than the uptakes in the developing countries. The other drawback of the thyroid uptake test is that it is affected by the iodine containing drugs. Anti-diarrhoea medications are quite common in the developing countries and many of them contain iodine moiety. Without a reliable drug history, a low thyroid uptake value may lead to a misleading conclusion.

The test also produces variable results with methodological changes. Distance of probe from the neck, counting of standard in an appropriate phantom, body background, stability of spectrometer - these are some of the critical factors affecting results of the investigation. As early as 1962, IAEA published recommendation after an advisory group meeting where an ideal protocol was described for performing this test. Unless these recommendations are strictly adhered to, it is not possible to obtain reliable results.

The uptake study at one single time is not likely to lead to an accurate diagnosis. Early uptake, say at two hours, if rapid and high, indicates thyrotoxicosis. 24 hrs uptake as a single parameter may miss some of the toxic patients because a very high uptake may return to normal by that time. 48 hrs uptake is helpful in finding the rate of turnover of the radioiodine in the thyroid gland. Thus, no single time period is pathognomonic for hyperthyroidism. Any single value is a resultant of trapping, hormonogenesis and washout of the radioiodine from the thyroid gland. No single value but a set of values obtained at different times is more helpful in the diagnosis.

Whenever the amount of stable iodine in the thyroid gland is low, the radioiodine enters a contracted pool of iodine in the gland, in which the turnover of the radioiodine is rapid, and as a result the uptakes are high, in spite of the fact that the thyroid function is basically normal. After surgery also the gland is physically reduced in size which has the same effect as the contracted pool of the radioiodine.

Some variations of the basic thyroid uptake tests are mentioned below but without details of the procedures because they are carried out very infrequently.

(a) **Neck - thigh ratio** is designed to eliminate the influence of high body background in the early stage.

(b) **Thyroid clearance test** measures the rate of clearance of radioiodine from the circulation after an i.v. injection of the radioisotope.

Thyroid clearance in ml/min = Thyroid uptake(150 min) - thyroid uptake(60 min) / 90 x plasma radioactivity (% dose/ml at 105 min)

(c) **urinary excretion of the radioiodine.** Assumption is that what is not picked up by the thyroid gland is eventually excreted in the urine. However, collection of the urine for 24 or 48 hrs is not likely to be reliable.

(d) $^{99}Tc^{m}$ thyroid uptake has not been very popular because this radioisotope is not a physiological counterpart of radioiodine, although it is avidly picked up by the thyroid gland. Early uptake after an i.v. injection shows the rate of trapping of the radioisotope by the gland and helpful in the diagnosis of hyperthyroidism.

Tests for estimating the level of the thyroid hormone in the blood.

(a) <u>$PB^{131}I$</u> measures the protein bound iodine as % of the administered dose per litre of plasma. It is a crude measure of the circulating thyroid hormone and is affected by the size of the stable iodine pool in the thyroid.

(b) <u>T3 RBC uptake, T3 Resin, T3 charcoal, T3 sephadex.</u> They are all variants of the competitive protein binding assays but not as elaborate as RIA. Their greatest drawback is that they are all affected by the levels of the thyroxine binding globulin in blood and therefore not of any use in pregnant women or in patients taking oestrogens.

(c) RIA of the T3, T4 and TSH. They are discussed separately in another chapter. These assays provide the most direct measure of the circulating thyroid hormone. TSH is the single most important test for diagnosis of the hypothyroidism. Estimation of the T3 levels is useful for diagnosis of T3 toxicosis. This is a condition where T4 levels are normal and the hyperthyroid state is mainly due to high T3. Its incidence is expected to be high in the developing countries because of the endemic iodine deficiency, where the gland produces more of T3 than T4 to conserve iodine.

Test to detect autonomous function of the thyroid gland.

(a) T3 suppression. Involves giving 75 μg of T3 daily for 7 days. Thyroid uptake has to be done before and after this regime. The second thyroid uptake will not be suppressed if the gland is autonomous. In developing countries, it is difficult to obtain T3. T4 can be used instead of T3. 300 μg of T4 are required to be given daily for 3 weeks.

(b) Autonomous thyroid nodule is diagnosed on the basis of thyroid scan. In this condition, the palpable nodule will show good concentration of radioiodine. T3 or T4 suppression regime will not show suppression of the concentration in the thyroid nodule on the second scan.

Tests to detect the hypermetabolic state of the patient.

Except Basal Metabolic Rate, there is no other test which can be used for this purpose.

Rational use of thyroid function tests needs sound understanding of thyroid physiology. Each test studies only one step in iodine metabolism. There is no single test which evaluates the overall thyroid function. Laboratory diagnosis of the thyroid function is a highly developed art. A clinician should judiciously select few tests which would lead him to the diagnosis without much cost in time and money. When one does more than one test, paradoxical and discrepant results are not rare. That is the challenge and fun of being a thyroid expert. Above all, a good clinical examination of patient is most essential before deciding which tests to order for evaluation of the thyroid function. All tests supplement clinical examination, nothing supplants it. That is why most nuclear medicine specialists end up being thyroid experts also.

CHAPTER 22

PROTOCOL FOR THYROID UPTAKE TEST.

Object:

To measure the percent uptake of a tracer dose of ^{131}I by the thyroid gland. This is the simplest and most widely used test to evaluate the thyroid function. After oral administration of radio-iodine, the 2, 24, 48 hour uptake measurements are done to see the rate of uptake, total build up and discharge of radioiodine by the thyroid gland.

Materials:

1. Spectrometer.
2. Flat Field Collimated scintillation crystal probe.
3. Standard Phantom.
4. Standard lead shield; 4" x 4" x ½".
5. Marker.
6. Carrier-free sodium iodide (^{131}I) capsules-25 μCi.

Calibration:

1. Switch on the main supply and power switches on the Spectrometer.
2. After 1-2 minutes, switch on the High Voltage.
3. Increase the H.V. to optimum value.
4. Set the amplifier Gain.
5. Let the instrument stabilize for at least ½ hr.
6. Put the Intg./Diff. switch on Differential and window on 1.0 V.
7. Keep the standard capsule in the phantom 30 cm away from the probe, and find out the photo peak for ^{131}I starting from base line 300 and increasing by intervals of 0.5 V (i.e. 5 divisions) and each time counting for 50 seconds, till the maximum counts are obtained. (Calibration procedures may vary from instrument to instrument). Note the Base line reading.

8. Set the window from 1.0 V to 5 V and decrease the base line setting by 20 divisions. (ie. at 1 V the Base line is 360, hence at 5 V the Base line is 360 - 20 = 340).

9. Count all the capsules, and discard those which show gross discrepancy in counts.

10. Keep one capsule as STANDARD; the remaining capsules are used in patients to study their respective uptakes.

Uptake Measurement:

1. Count the Standard capsule by keeping it in a phantom 30 cm away from the probe by means of a marker. Take 2 readings of 2 minutes each. Calculate cpm. (S1).

2. Place the standard shield near the capsule and count the standard again for 2 minutes. Calculate cpm. (S2).

3. S1 - S2 = Net counts of the standard capsule.

4. Administer the radioiodine capsule to the patient after screening.

5. Two hours later, count the patient's neck, keeping a distance of 30 cm from the probe. Take 2 readings of 2 minutes each. Calculate cpm. (P1).

6. Ask the patient to hold the standard shield in front of the neck. Count for 2 minutes. Calculate cpm. (P2).

7. P1 - P2 = Net counts of the patient's thyroid.

8. $$\% \text{ uptake in the thyroid} = \frac{P1-P2}{S1-S2} \times 100$$

9. Repeat the counting at 24 hours and 48 hours, and calculate the % uptakes.

Limitation of the technique:

1. The test cannot be done in children and pregnant women.

2. Radiation hazard to the patient (?)

Pitfalls of the technique:

1. The prior administration of iodine containing drugs, thyroid hormones, antithyroid drugs, and several other compounds, may invalidate the test for a number of weeks to months.

2. Serial readings are necessary for 3 days for proper diagnosis.

Highlights of the technique:

1. Simple test.

2. Gives dynamic functional information.

SUGGESTED READING.

[1] International Atomic Energy Agency, Proc. Consultants' meeting on the calibration of thyroid measurements. Br. J. Radiol, 35 (1962) 205.