Correlation of Thyroid Hormone Levels with Radioactive $^{99m}$Tc Thyroid Uptakes

Waddah M. Ali1*, Mohamed Yousef2,3, Mohammed A. Ali Omer 3,4, M. E. M. Gar-alnabi 3, Bushra Ahmed1

1College of Radiologic Technology, The National Ribat University, Khartoum Sudan
2College of Applied Science, Taibah University, Almadinah Almunawarah, KSA
3College of Medical Radiologic Science, Sudan University of Science and Technology, Khartoum-Sudan.
4College of Applied Medical Science, Qassim University, Buraydah-KSA.

Abstract

Objective: This study aimed to study the relationship between thyroid function test and thyroid uptake using $^{99m}$Tc and to determine of the normal range of the thyroid uptake in Sudanese as well as the possibility of replacing the TFT test by thyroid uptake.

Methods: Out of the 77 patients (6.2% males and 93.5%) females who referred to the department of nuclear medicine at radio isotope center Khartoum (RICK) for thyroid function test and thyroid scan in the period from May to Aug 2009, were included in this study. Simple sensitive RIA was used for the measurement of thyroid related hormones (T4, T3 and TSH), and thyroid uptake value in the gamma camera (mediso).

Results: The results showed that mean±SD values for T3, T4, TSH and thyroid uptake were 5.6±3.6, 79.8±6.5, 6.7±0.8 and 6.3±2.4 respectively. The normal range for thyroid uptake in this study was ranged from 5.78 to 6.12% at 20 min after injected with a dose of 3mCi $^{99m}$Tc. As well as the results showed that there is strong and significant correlation at p = 0.05 between the thyroid uptake versus T3 and T4. Whereas in low uptake the correlation coefficient r = 0.87 and 0.81 for T4 and T3 respectively, and in elevated group r = 0.94 for T4 and 0.96 for T3. While in the normal uptake group r = 0.99 and 0.88 for T4 and T3 respectively. This study concluded that there was relationship between thyroid uptake and the level of the thyroid related hormones The percentage of thyroid uptake was ranging between 1.2 and 8.0

Conclusion: There were possibilities of using thyroid uptake only as a diagnostic tool for thyroid activity

Key words: Thyroid uptake, thyroid function test (TFT), thyroxin hormone (T4), triiodothyrosin hormone (T3), thyroid stimulating hormones (TSH), radioactive technetium ($^{99m}$Tc), radioimmunoassay (RIA).

I. Introduction:

Over the past forty years, improvements in the sensitivity and specificity of thyroid testing methodologies have dramatically impacted clinical strategies for detecting and treating thyroid disorders. In the 1950s, only one thyroid test was available – an indirect estimate of the serum total (free + protein-bound) thyroxine (T4) concentration, using the protein bound iodine (PBI) technique (1,2). Since 1970, technological advances in radioimmunoassay (RIA) and more recently immunometric assay (IMA) and tandem mass spectrometry methodologies have progressively improved the specificity, reproducibility and sensitivity of thyroid testing methods (3-10). Currently, serum-based immunoassay and tandem mass spectrometric methods are available for measuring both total T4 (T4) and total triiodothyronine (TT3) concentrations as well as the free hormone moieties (FT4 and FT3) (11-13). In addition, measurements can be made of the thyroid hormone binding proteins, Thyroxine Binding Globulin (TBG), Transthyretin (TTR)/Prealbumin (TBPA) and Albumin, as well as for the pituitary thyroid stimulator, Thyrotropin (thyroid stimulating hormone, TSH) and the thyroid hormone precursor protein, Thyroglobulin (Tg) (14-16). The recognition that autoimmunity represents a major cause of thyroid dysfunction has led to the development of tests for the detection of thyroid autoantibodies such as thyroid peroxidase antibodies (TPOAb), thyroglobulin antibodies (TgAb) and TSH receptor antibodies (TRAb) (17-19). Currently, these thyroid tests are performed on serum specimens using either manual or automated methods employing specific antibody reagents directed at these ligands (6,20). However, sensitivity, specificity and standardization issues still result in substantial between-method variability for many of these tests (21-23). To address this issue, new performance standards are being established by the professional organizations as well as technological advancements undertaken by instrument manufacturers (24-26).

Thyroid gland function and structure can be evaluated using uptake and scintigraphy studies. $^{131}$I-iodide, which was introduced in the late thirties, was the first radiopharmaceutical used for measuring thyroid uptake, and for many years it was the main study agent used in the evaluation of thyroid function. (27) Despite the fact that the sensitivity and specificity of in vitro tests for evaluation of thyroid function have evolved, thyroid uptake and scintigraphy still play an important role in various clinical situations, such as the detection of ectopic
thyroid tissue in neck masses, functional assessment of single or multiple nodules, increasing the likelihood of detecting hyperthyroidism in difficult cases, identification of other causes of thyrotoxicosis and calculation of therapeutic doses of $^{131}$I-iodide. Studies with $^{131}$I-iodide have the serious disadvantage of high radiation doses to the gland (1343 rad/mCi administered) caused by its long half-life and b particle emission. Its main gamma photon has high energy (364 keV) that is inadequately collimated by most conventional scintillation cameras, and therefore poor quality images are produced. In the United States, the use of $^{131}$I-iodide for thyroid imaging has been prohibited and its use restricted to staging and follow-up of patients with differentiated thyroid carcinoma. $^{123}$Iodine-123 is a good substitute for iodine-131 because it has a shorter half-life (13 hours), a gamma photon suitable for imaging conventional scintillation cameras (159 keV) and no b radiation. However, its main limitations are its high cost and reduced availability, due to its expensive and complex production in a cyclotron. In addition, depending on the production process chosen, contaminants such as $^{124}$I-iodide and $^{125}$I-iodide may be formed increasing the dosimetry and image degradation. $^{125}$TcTechnetium$^{99m}$m, in the chemical form of pertechnetate ($^{99m}$TcO$_4^-$), is also used for thyroid scintigraphy and uptake. The similarity of volume and charge between the iodide and pertechnetate ions is the explanation for the uptake of $^{99m}$Tc-pertechnetate by the thyroid gland. $^{99m}$Tc-pertechnetate has been used worldwide to study the thyroid function because of a number of advantages, such as a short half-life (6 hours), short retention in the gland, and no b radiation, thus providing low dosimetry to the thyroid gland (10,000 times less than that of $^{131}$I-iodide), as well as to the body as a whole. Its gamma photon of 140 keV is ideal for imaging using scintillation cameras and in addition it has low cost and is readily available. There is an international consensus that the radiochemicals of choice for thyroid gland imaging are $^{99m}$Tc-pertechnetate or $^{125}$I-iodide. Although the thyroid does not organify $^{99m}$Tc-pertechnetate, in the majority of cases the uptake and imaging data provide all the information needed for accurate diagnosis. In rare instances, $^{125}$I-iodine can subsequently be used for assessment of organification defects. Despite these recommendations, most nuclear medicine laboratories in Brazil choose the radiochemicals of $^{125}$I-iodide to study the thyroid gland. This practice can in part be explained by the fact that there is a lack of standard values for $^{99m}$Tc-pertechnetate uptake by the thyroid gland. This study aimed to study the relationship between thyroid function test and thyroid uptake using $^{99m}$Tc and to determine of the normal range of the thyroid uptake in Sudanese as well as the possibility of replacing the TFT test by thyroid uptake.

II. Materials and methods:

This study was conducted in Nuclear Medicine Department, Radiation and Isotope Center of Khartoum (RICK) from 2007 to 2010. A total of 77 patients (6.5%) were males and (93.5%) were females and the average age of the patients studied was 20 years. The peak incidence was among the age between 21-30 years of age presenting the percent of (52%) referred to the department for thyroid scan from march to July 2009 were included in this study, correlated with thyroid function tests. The scintigraphies were all obtained by using Nucline gamma camera computer system (planer and dual head whole body SPECT) with general purpose collimators made in Hungary. Generator UltraTechneKow® FM DRN 432999Mo/99mTc Generator Composition (elute) 99Mo content < 25 Bq/MBq 99mTc. Specifica1tions are within the guidlines described by monographs of the U.S.A. and the European Pharmacopoeia PH 5.0 – 7.0 ,10-20 minutes after intravenous injection of 37-111MBq of sodiumpertechnetate$^{99m}$m. All radioimmunoassay using RIA instrument which include SOURCERER RIA gamma counter, manufactured by OAKFIED Company, England in 1992 and specific reagents for the measurement of thyroid hormones were obtained from China Institute for Atomic Energy (CIAE), Department of Isotopes (Beijing China).used in RIA were including Adjustable micropipettes. (10-200µl), Polystyrene test tubes (disposable), Vortex mixer (single and multi-tubes), Multidose micropipette (Eppendorff), 25µl and 250 µl, magnetic base, Incubator, Centrifuge and Gamma counter (connected with computer. Five ml of blood sample were drowning from the patient in RIA laboratory for thyroid related hormones (T4, T3 and TSH) assay using Gamma counter. Then the patients were divided into three groups according to their thyroid hormones assay results. Group I consisted of 42 patients whose hormones levels were normal. Group II contained of 18 patients with low thyroid hormones level, and Group III consisting of 17 patients with high thyroid hormones level. Ultimately all the patients were enrolled in nuclear thyroid uptake test; where patients were injected with 3 to 5 mCi pure technetium pertechnetate, followed by full and empty syringe image for one minute to measure the net amount of activity entered to the patient’s blood stream, 15 to 20 minute later the patient positioned supine in the gamma camera table with 15 to 30 cm distance using gamma camera fitted with LEGP collimators and anterior image for one minute were taken, then by using DIAG program the amount of thyroid uptake were calculated.
III. Result:

The result of this study showed that, there was a direct relationship between thyroid uptake and the level of the thyroid related hormones (for individual). There is strong and significant correlation at $p = 0.05$ between the thyroid uptake versus T3 and T4. The percentage of thyroid uptake for the subjects included in the study was ranging between 5.78 and 6.12.

![Figure 1](image1.png)

Figure (1) shows the relationship between T3 and thyroid uptake

![Figure 2](image2.png)

Figure (2) shows the relationship between T4 and thyroid uptake

Table 1 shows the mean and standard deviation for all groups

<table>
<thead>
<tr>
<th>variables</th>
<th>Mean ±SD</th>
<th>Mean ±SD</th>
<th>Mean ±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal group</td>
<td>High group</td>
<td>Low group</td>
<td></td>
</tr>
<tr>
<td>uptake</td>
<td>5.9±0.2</td>
<td>10±0.2</td>
<td>3.45±0.1</td>
</tr>
<tr>
<td>T3</td>
<td>4.8±0.1</td>
<td>8.8±0.6</td>
<td>1.52±0.2</td>
</tr>
<tr>
<td>T4</td>
<td>61.6±3.2</td>
<td>172.3±10.7</td>
<td>1.65±0.1</td>
</tr>
<tr>
<td>TSH</td>
<td>1.4±0.1</td>
<td>0.74±0.2</td>
<td>1.1±0.2</td>
</tr>
</tbody>
</table>

IV. Discussion:

The radiopharmaceuticals currently chosen are $^{99mTc}$-pertechnetate has become the tracer of choice, since it is readily available and has a low cost. Its uptake is similar to that of iodide, although ion organization is absent. The maximum thyroid uptake of $^{99mTc}$-pertechnetate takes place 10 to 20 minutes after intravenous injection, in contrast to $^{131I}$-iodide, which requires a 24-hour measurement period. In the present study, 77 patients categorized into three groups depending on hormones level. The result of this study showed that the mean±SD values for T3, T4, TSH and thyroid uptake were 5.6±3.6, 79.8±6.5, 6.7±0.8 and 6.3±2.4 respectively. The normal range for thyroid uptake in this study was ranged from 5.78 to 6.12% at 20 min after injected with a dose of 3mCi $^{99mTc}$. As well as the results showed that there is strong and significant correlation at $p = 0.05$ between the thyroid uptake versus T3 and T4. Whereas in low uptake the correlation coefficient $r = 0.87$ and 0.81 for T4 and T3 respectively, and in elevated group $r = 0.94$ for T4 and 0.96 for T3. While in the normal uptake group $r = 0.99$ and 0.88 for T4 and T3 respectively. The strong and significant correlation between the T3, T4 and thyroid uptake was expected because the uptake of thyroid gland physiologically, have direct proportionality with the amount
of thyroid hormones syntheses by the thyroid gland. Therefore in case of low hormones level the uptake of thyroid is low due to the smallest number of thyroid gland cells act in trapping and syntheses of thyroid hormones, while at elevated hormones level mean that the number of thyroid cell act as syntheses increase so the uptake was increased. There were insignificant correlation between the thyroid uptake and TSH level; this is because a lot of patients have no problem in thyroid stimulating hormones TSH but the problem within thyroid cells mainly due to iodine deficiency. In most cases the patients have normal TSH but have problem in the other hormones as well as the uptake result; this mean that the TSH does not reflect the status of the thyroid disorder. Therefore there is no obvious linear association between TSH and uptake, as the one shown by T3 and T4. The linear relationship between thyroid uptake and T3 showed a coefficient equal to 0.65 uptake%/nmolL and a constant equal to 2.6 as shown in the following equation: uptake% = 0.647 T3 + 2.6859. In case of T4 the coefficient equal to 0.04 uptake%/nmolL with a constant equal to 3.6 as shown by the following equation: uptake% = 0.0365 T4nmolL + 3.5861. From the above result, thyroid uptake test can be used to diagnosis and evaluate the thyroid disorder because the uptake result gives an accurate indication about the thyroid hormones status in low, normal or elevated thyroid hormones level, without the use of TFT, so that we can decrease both the time for diagnosing the patient and the cost. In summary the study showed that TFT result can be estimated using thyroid uptake as well thyroid uptake can reveal global and specific diagnostic information concerning thyroid status.

References

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