ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 11, Issue, 08, pp.6214-6217, August, 2019

DOI: https://doi.org/10.24941/ijcr.36252.08.2019

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

MEASUREMENT OF Tc-99m PERTECHNETATE THYROID UPTAKE BY DIFFERENT METHODS USING GAMMA CAMERA AND UPTAKE PROBE

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ARTICLE INFO

Article History:
Received 20th May, 2019
Received in revised form
14th June, 2019
Accepted 18th July, 2019
Published online 31st August, 2019

Key Words:

Gamma camera,
Thyroid uptake probe,
Thyroid uptake.

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ABSTRACT

Introduction: Technetium-99m pertechnetate is the most readily available radionuclide employed for thyroid uptake using gamma camera, which provides an assessment of the trapping ability of the gland. The present study was carried out to compare Tc-99m pertechnetate thyroid uptake values by three different protocols (gamma camera, uptake probe using computer software and uptake probe using manual method). ***Material and Methods:*** This prospective study was performed in twenty seven consecutive patients (5 males and 22 females) using three different protocols and two different modalities ie. Gamma camera and uptake probe. After intravenous administration the mean time taken for the uptake on gamma camera and thyroid uptake probe was 30 ± 10.02 minutes (range 20-52 minutes) and 32.1± 12.65 minutes (range 21-75 minutes). ***Results:*** The mean uptake values and standard deviation calculated using thyroid uptake probe with computer software and Manual method (8.1±6.1, and 8.06±5.9) were slightly higher than uptake values calculated using Gamma camera (5.8±6.2). The correlation (r) between probe and manual uptake, gamma camera and manual uptake, and gamma camera and probe were 0.9947, 0.9691 and 0.9625 respectively. The correlation coefficient between all the three uptake methods is very high and shows a positive trend. Authors observed that the uptake values evaluated by the two modalities co-relate well but their mean values are different significantly. However, there is not much difference between the uptake values calculated using the probe software and the manual calculation formula. ***Conclusion:*** The uptake probe can be routinely used for thyroid uptake calculation using Tc-99m pertechnetate. But standardization of the thyroid uptake using pertechnetate needs to be performed before putting this for patient's routine use. The gamma camera underestimates the thyroid uptake than the probe but provides the thyroid image for the size and shape evaluation.

Citation: Nisha Bhatia, Sarika Prashar, Baljinder Singh and Devinder Kumar Dhawan, **2019.** "Measurement of Tc-99m pertechnetate Thyroid Uptake by different methods using Gamma Camera and Uptake Probe", *International Journal of Current Research*, 11, (08), 6214-6217.

INTRODUCTION

Thyroid uptake provides quantitative assessment of trapping ability of the thyroid gland. Standard practice for calculating the radioiodine therapy dose is based on thyroid radioiodine uptake studies using I-131 or I-123. Pertechnetate ions (TcO^{-4}) are trapped by the thyroid in the same manner as iodine through an active iodine transporter, but pertechnetate ions are not organified. Radioiodine I-131 and I-123 are both trapped and organified by the thyroid gland, allowing overall assessment of thyroid function (Kusic *et al.,* 1990). Radioiodine (I-131 & I-123) and Tc-99m pertechnetate provide similar information. So Tc-99m pertechnetate can be used as an alternative to radioiodine (I-131 & I-123) to calculate thyroid uptake due its favourable characteristics like a short retention in the gland which serves as a fast method to calculate thyroid uptake, and no beta radiation, thus providing less radiation to the thyroid gland as well as to the body as a whole. In addition it has low cost and is readily available.

Usually for calculation of I-131 therapy dose, thyroid radioiodine uptake studies are done by using non-imaging gamma probe at 24-48 hrs of administration of oral radioiodine dose (I-131 & I-123). These gamma probes are scintillation detectors having high detection sensitivity, extremely collimated and cheaper than scintillation cameras, but they cannot permit image registration (Meier, 2001). Since last few decades, nuclear medicine departments are using scintillation cameras also called gamma camera to perform thyroid uptake measurement studies using Tc-99m pertechnetate (Benjamin *et al.,* 1999). Such devices are required for every nuclear medicine procedure. They have excellent spatial resolution and a very small probability of producing artifacts and permit image registration too. And by using Tc-99m pertechnetate, thyroid uptake can be measured at 20-30 min of dose administration. The present study was carried out to compare Tc-99m thyroid uptake values by different methods (gamma camera, uptake probe using computer software and uptake probe using manual method) in patients with thyroid dysfunction.

MATERIALS AND METHODS

This prospective study was performed in twenty seven consecutive patients which includes 5 males and 22 females with Mean age ± SD; 40.8 ±14.7 yrs and range (12-65yrs). The radioisotope used for thyroid uptake measurement was Tc-99m pertechnetate. The thyroid Tc-99m uptake was measured using gamma camera (GE; Millenium MPR) fitted with a (Low Energy General Purpose) LEGP collimator and thyroid uptake probe (Capintec, Inc. Captus 3000 Version1.19). Pre syringe and post syringe counts of measured dose of Tc-99m pertechnetate were taken before and after administration of dose on both gamma camera and thyroid uptake probe. At twenty to thirty minutes of intravenous administration of 111-158 MBq (3- to 4-mCi) Tc-99m pertechnetate, uptake was measured on gamma camera and thyroid uptake probe. On gamma camera, static thyroid images were obtained in anterior view while the patient was supine with the neck extended. Image data acquisition was done in 128 x 128 computer matrix (zoom=1). Counts for injection site were also taken using 128×128 computer matrix for 60 seconds in order to check for subcutaneous infiltration that could invalidate the uptake calculation.

For analysis of Tc-99m pertechnetate thyroid uptake studies on gamma camera a region of interest was manually placed over the thyroid on each image. The counts per region of interest on each image were corrected for radioactive decay. The Tc-99m pertechnetate thyroid uptake was calculated by using computer algorithm provided by the manufacturer for thyroid uptake applications (Figure 1). On thyroid uptake probe patients were seated facing the detector, which was positioned 25 cm from the anterior surface of the patient's neck at the level of the cricoid. Counts were obtained in duplicate at the patient's neck for 30 seconds and the patient's background counts for 30 seconds (Figure 2). The Tc-99m pertechnetate uptake was calculated using the probe inbuilt thyroid uptake software and manual calculations with the following relationship:

Tc-99m pertechnetate uptake =

$$\frac{\text{Neck Counts (cpm)} - \text{Background Counts (cpm)}}{\text{Administered Dose Counts (cpm)} - \text{Background Counts (cpm)}} \times 100\%.$$

Statistical analysis: Mean, standard deviation and data destrictive values were used for the relevant values. Correlation coefficient was calculated between gamma camera, probe and manual method.

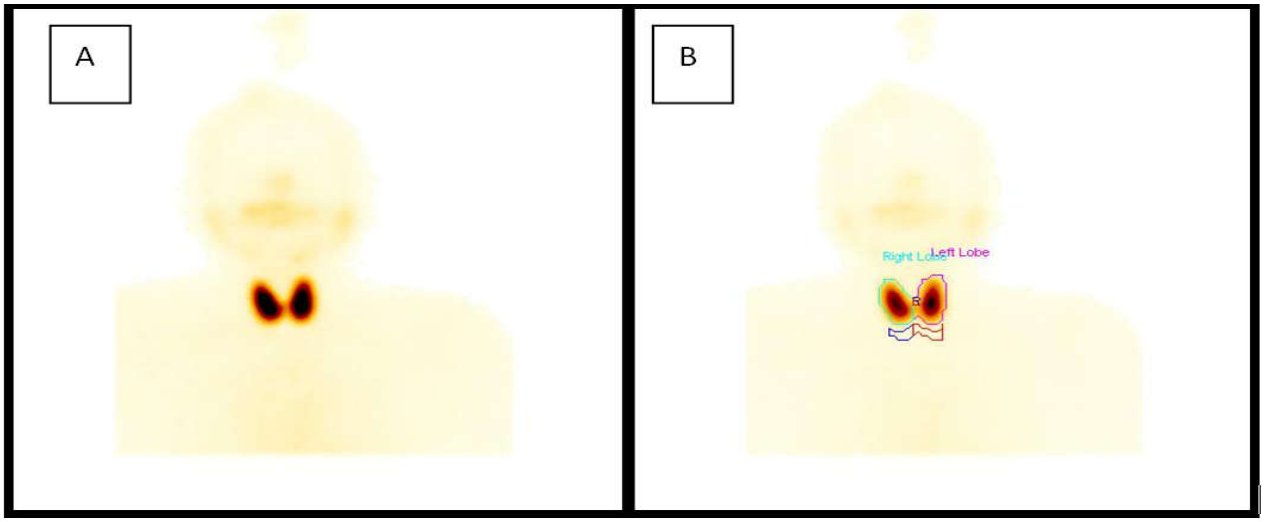

Figure 1 Procedure used for determining number of counts present in the thyroid in order to obtain the Tc-99m pertechnetate thyroid uptake on gamma camera. A: raw image obtained in the anterior view, B: For processing of image thyroid region of interest (roi) and background roi were drawn manually , thyroid uptake value calculated using computer algorithm is 10.1 %.

Figure 2 Procedure used for determining number of counts present in the thyroid in order to obtain the Tc-99m pertechnetate thyroid uptake on thyroid uptake probe. A. Background counts acquisition of the patient's neck using lead shield on thyroid uptake probe. B. Thyroid counts acquisition of the patient's neck using thyroid uptake probe.

Comparison of mean (student t test) was used to calculate the significance of difference in the various uptake methods. The value was considered significant only when $p < 0.05$.

RESULTS

Ten of the twenty seven patients were suffering from grave's disease, ten with hyperthyroidism, four thyrotoxicosis with multinodular goiter (MNG), one euthyroid, and two thyroditis. Distribution of patients according to their diseases is shown in Figure 3. Patients were injected intravenously with Tc-99m pertechnetate of mean activity ± SD; 3.32±0.34 mCi. Activity was measured using calibrated dose calibrator, before injecting to the patients. The mean uptake values and standard deviation for the patients using gamma camera (GE; Millenium MPR) fitted with a (Low Energy General Purpose) collimator, calibrated thyroid probe (Capintec, Inc. Captus 3000 Version1.19), and manual method were 5.8±6.2, 8.1±6.1, and 8.06±5.9 respectively also shown in Table 1. Comparison of mean (student t test) was used to calculate the significance of difference in the various uptake methods and the values are shown in Table 2. Correlation coefficient was calculated between gamma camera, uptake probe using computer software and uptake probe using manual method and the calculated values are shown in Table 3.

Table 1 the mean uptake values and standard deviation

S. No.	Type of Method	Mean Uptake	Standard Deviation	Minimum Uptake	Maximum Uptake
01	Gamma Camera	5.8	6.19	0.1	20
02	Uptake Probe (computer software)	8.1	6.16	1.6	23.8
03	Uptake Probe (Manual Method)	8.06	5.95	1.6	22

Table 2 Comparison of mean (student t test) in the various uptake methods and the values

	GC & Probe	GC & Manual	Probe & Manual
Difference	2.3296	2.2152	0.1144
Standard Error	1.5799	1.4422	0.5821
95% cl	1.7047 to 2.9546	1.6447 to 2.7857	-0.1158 to 0.3447
Test Statistic	7.662	7.981	1.022
DF	26	26	26
Significance level	P < 0.0001	P < 0.0001	P = 0.3164

Table 3 Correlation coefficient between gamma camera, probe and manual method

	Probe and manual	GC and manual	GC and probe
Sample size	27	27	27
Correlation coefficient r	0.9947	0.9691	0.9625
Significance level	P<0.0001	P<0.0001	P<0.0001
95% Confidence interval for r	0.9881 to 0.9976	0.9325 to 0.9860	0.9184 to 0.9830

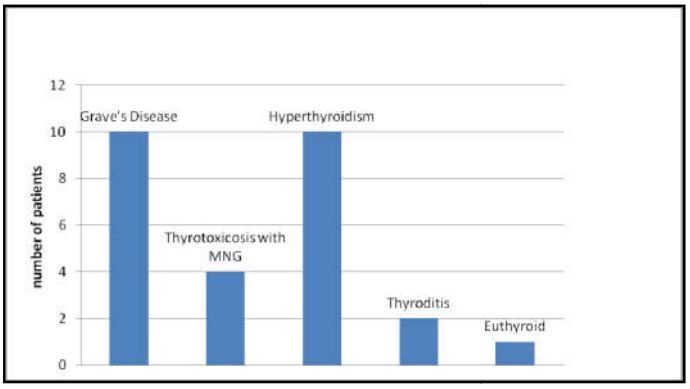

Figure 3. Distribution of patients according to their disease

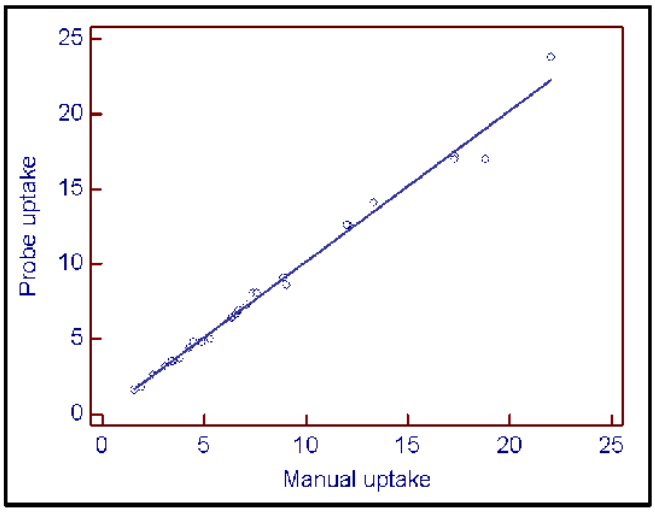

Figure 4. Correlation graph between uptake on the probe and manual calculation. The correlation coefficient = 0.9947 at p < 0.0001

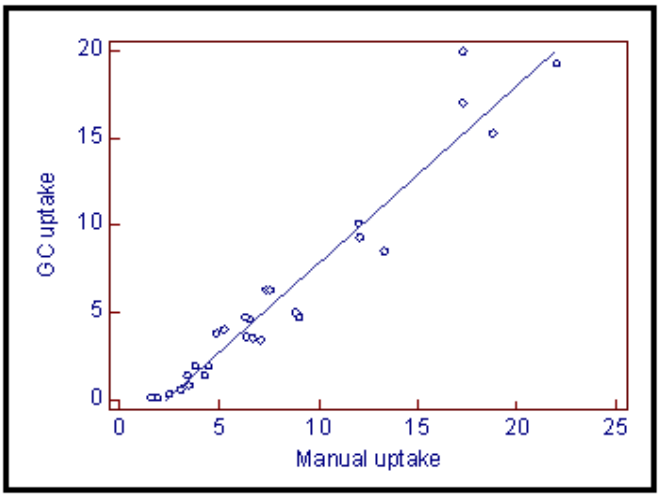

Figure 5. Correlation graph between uptake on the gamma camera and manual calculation. The correlation coefficient = 0.9691 at p < 0.0001

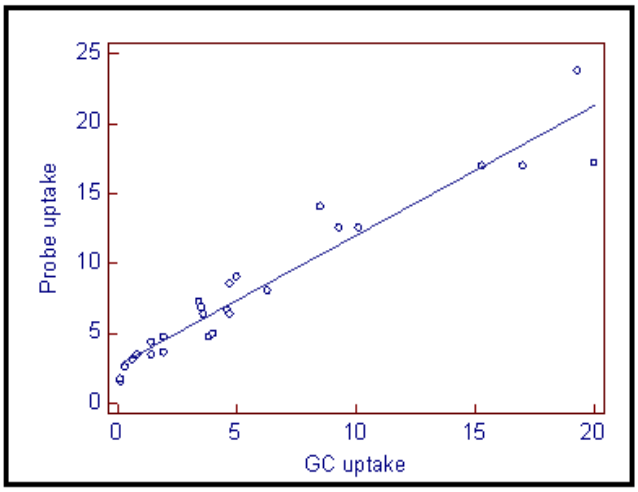

Figure 6. Correlation graph between uptake on the gamma camera and probe uptake calculation. The correlation coefficient = 0.9625 at p < 0.0001

The correlation graph between the various uptake were drawn and shown as graph in Figure 4, Figure 5, Figure 6. Comparison of the gamma camera uptake, manual uptake and probe uptake was drawn and shown in Figure 7.

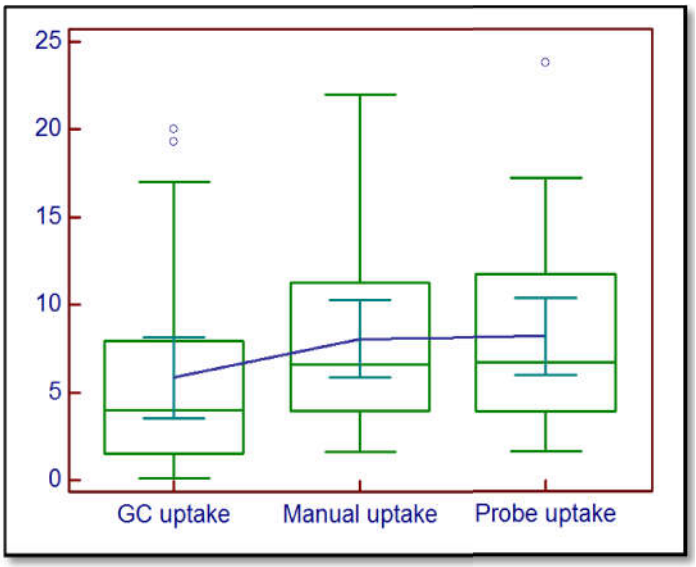

Figure 7. Comparison of the gamma camera uptake, manual uptake and probe uptake.

DISCUSSION

The thyroid uptake is one of the important parameters for quantitative evaluation of functional status of thyroid gland (Smith *et al.,* 1990; Sucupira *et al.,* 1983). The thyroid uptake is generally performed on thyroid uptake probe. However gamma camera is nowadays also available with uptake calculation software. In the present study the thyroid uptake with Tc-99m pertechnetate was calculated using three different protocols and two different modalities ie. gamma camera and uptake probe. The twenty seven patients suffering from various thyroid diseases were included in this study. Only one euthyroid patient was included with T_3, T_4, TSH values as 1.93, 11.48 and < 0.005 respectively. Remaining twenty six patients has various degrees of thyroid disfunctionality. The mean uptake of the thyroid with Tc-99m pertechnetate using gamma camera is 5.8± 6.19% (range 0.1 to 20). The mean uptake with Tc-99m pertechnetate using uptake probe is 8.1± 6.16 % and with manual uptake calculation is 8.06± 5.95 %. Using the paired t-test between the uptake on gamma camera and uptake probe the mean difference is 2.33% and t value = 7.662. There is a significant difference between the mean uptake values on the two modalities with p< 0.0001. The mean difference between gamma camera and manual uptake method is 2.22% and t value is 7.981. There is a significant difference between the mean uptake values desired by the two methods with p<0.0001. There is no difference between the uptake values on the probe using probe software and manual calculation as shown in Figure 7. Technetium-99m pertechnetate is the most readily available radionuclide employed for thyroid imaging. Pertechnetate ions (TcO^{-4}) are trapped by the thyroid in the same manner as iodine through an active iodine transporter, but Tc-99m pertechnetate ions are not organified. The literature suggests that Tc-99m pertechnetate gets washed out of the gland and hence allows standard time for uptake measurement within 20 to 30min (Smith *et al.,* 1990; Sucupira *et al.,* 1983; Ramos *et al.,* 2002). In this study, after intravenous administration the mean time taken for the uptake on gamma camera was 30 ± 10.02 minutes (range 20- 52 minutes). The mean time taken for the uptake on a probe system was 32.1± 12.65 minutes (range 21-75 minutes). The patient who was late for gamma camera uptake was also late for the probe method. The uptake values however for gamma camera was 6.3% at 52 minutes and 8.1% at 75 min for the uptake probe. The correlation coefficient between all the three uptake methods is very high and shows a positive trend. The correlation (r) between probe and manual uptake, gamma camera and manual uptake, and gamma camera and probe are 0.9947, 0.9691 and 0.9625 respectively. Similar results for correlation coefficient values ranging from 0.912-0.988 were observed by Benjamin R. S. et al in 1999 for measurement of thyroid uptake on gamma camera and thyroid uptake probe using radioiodine I-123 (Benjamin *et al.,* 1999). Results of the present study suggest that the uptake values evaluated by the two modalities (gamma camera and thyroid uptake probe) co-relate well but their mean values are different significantly. Also, the uptake on gamma camera is underestimated than the uptake probe for Tc-99m pertechnetate thyroid uptake. However, there is not much difference between the uptake values calculated using the probe software and the manual calculation formula. So in heavy volume departments where patients workload on gamma camera machine is high, Tc-99m pertechnetate thyroid uptake can be performed on thyroid uptake probe for patients who are not indicated for imaging and require thyroid uptake measurement only. But standardization of the thyroid uptake using Tc-99m pertechnetate needs to be performed before putting this for patient's routine use.

CONCLUSION

Uptake probe can be routinely used for thyroid uptake calculation using Tc-99m pertechnetate. This can be a simple and fast method for measurement of Tc-99m pertechnetate thyroid uptake using thyroid uptake probe with added advantages of low radiation dose, easy availability and low cost of Tc-99m pertechnetate. There is a need to establish normal uptake range of Tc-99m thyroid uptake which could be of significant clinical relevance.

CONFLICTS OF INTEREST: None
FINANCIAL FUNDING: None

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