"Comparison of Thyroid Uptake by Tc - 99m Pertechnetate and Iodine – 131 for Euthyroid & Hypothyroid Patients"

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ABSTRACT

Euthyroidism is defined as normal functioning thyroid gland that occurs with normal serum levels of TSH and T4. Lower than normal T4 levels usually mean its hypothyroidism. This thyroid condition can be treated with radioactive therapy using uptake studies by Iodine-131 and Tc-99m. Oral administration of I-131 has been a commonly accepted procedure for treatment of benign and malignant conditions of the thyroid since the 1940s. However, thyroid uptake using Tc-99m has proven to be more advantageous than with I-131, since the procedure is faster, short half-life (only 6 hours), short retention in the gland, no beta (-) radiation thus providing low dose to the thyroid gland (10000 times less than that of I-131) and the images have better quality for its gamma photon of 140keV. So the aim of this study was to make a comparison between I-131 and Tc-99m for performing thyroid uptake and to correlate them for both euthyroid and hypothyroid patients and hence to standardize a simple and fast method for performing thyroid uptake. This study was made for 87 patients (58 females and 29 males) with ages ranging from 14 to 75 years (mean of 39.2 years) were done with both I-131 and Tc-99m. The type of patients was euthyroid, hyperthyroid and hypothyroid. The correlation and comparison between I-131 and Tc-99m was studied for euthyroid and hypothyroid patients. From this study out of 87 patients 32 were found euthyroid, 12 were hypothyroid and others were hyperthyroid. Out of 32 euthyroid patients 26 patients were positive with both Tc-99m and I-131. 6 patients had negative results with Tc-99m and positive results with I-131. Out of 12 hypothyroid patients 10 patients were positive with both Tc-99m and I-131. 2 patients had negative results with Tc-99m and positive results with I-131. A statistically significant correlation was found between I-131 and Tc-99m data for euthyroid patients (r = 0.49, p-value = 0.005). But for hypothyroid patients (r = 0.56, p value = 0.058) which indicates statistically not significant correlation. Considering I-131 imaging as the gold-standard procedure, Tc-99m had a good correlation with I-131 for the detection of euthyroidism but not for the hypothyroidism. So, the consideration of thyroid structure and function using Tc-99m is a simple, fast, better and efficient method for euthyroid patients according to its advantages over I-131 and also for the good quality correlation of this study. To show better correlation for hypothyroidism; further study should be needed with more patients.

Keywords: Thyroid Stimulating Hormone (TSH), Thyroxine (T4), Differentiated Thyroid Carcinoma (DTC), Thyroid Peroxidase Antibodies (TPOAB), Single Photon Emission Computed Tomography (SPECT) etc.

INTRODUCTION

Thyroid uptake and imaging continues to play a vital role in different thyroid related clinical situations, since the discovery of I-131. There are a lot of thyroid patients in Bangladesh. A thyroid uptake is performed so that doctors or technologist can determine which parts of the thyroid gland are working properly and whether the thyroid gland is over-active (hyperthyroidism) or under-active (hypothyroidism) and also where it is normal (euthyroid). An underactive thyroid gland (hypothyroidism) is where thyroid gland doesn't produce enough hormones. Common signs of an underactive thyroid are tiredness, weight gain, feeling tense and depressed (Chapman, 1983).

In our country, thyroid uptake study is done in a number of medical College & hospitals under Bangladesh Atomic Energy Centre. Fifteen medical Colleges & hospitals work with this uptake under Bangladesh Atomic

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Energy Centre. Some private hospitals also conduct this uptake throughout the country. I have got the chance to work thyroid uptake under INMAS (Institute of Nuclear Medicine and Allied Sciences), Atomic Energy Centre, Dhaka Medical College Hospital Campus, Dhaka-1000.

Thyroid uptake determination is the measurement of the fraction of an administered amount of radioactive iodine that accumulates in the thyroid at selected times following ingestion. Beside this, it can be determined, using intravenously administered Tc-99m pertechnetate. The pharmaceutical part acts like a chemical that the body normally uses, so the body tissues take up the radiopharmaceutical. The radioactive part gives off radiation (gamma rays) that is detected by a special device known as gamma camera. These devices record the gamma rays given off, and then a computer uses this data to make an image. From image physician understand and can take decision about thyroid problem or disorder (Balon, Silberstein, et. al., 2006).

Studies with I-131 iodide have the serious disadvantage of high radiation doses to the gland (1-3 rad/mCi administered) caused by its long half-life beta (-) 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 I-131 iodide for thyroid imaging has been prohibited and its use restricted to staging and follow-up of patients with differentiated thyroid carcinoma. Iodine-123 is a good substitute for iodine-131 because it has a shorter half-life (13 hours), a gamma photon suitable for imaging using conventional scintillation cameras (159keV) and no beta (-) radiation. However, its main limitations are its high cost and reduced availability, due to its expensive and complex production in a cyclotron for Bangladesh perspective (Kenneth & Rosenthal, 2010).

Technetium-99m, in the chemical form of pertechnetate ($99mTcO_4^-$), 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 Tc-99m pertechnetate by the thyroid gland. Tc-99m 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 nobeta (-) 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 140keV is ideal for imaging using scintillation cameras and in addition it has low cost and is readily available (Murad, M.J.M., 2023). The similarity of the Technetium-99m pertechnetate ions and iodide is the explanation for thethyroid glands ability to absorb it. So, there is an international consensus that the radiopharmaceuticals of choice for thyroid gland imaging are Tc-99m pertechnetate or I-131. Therefore, this study had the aim of standardizing a simple and fast method for performing thyroid uptake and hence to identify which one is better for thyroid treatment.

LITERATURE REVIEW

I have found few papers regarding my research. Here I discuss those papers which help me to do my research work.

Al-Jabri, A., Cooke, J., Cournane, S., et. al., explained for radioactive Iodine-131 (^{131}I) treatments of thyroid diseases, increased efficacy has been reported for personalized dosimetry treatments. The measurement of Iodine-131 thyroid uptake (^{131}IU) is required in these cases. This study aims to investigate whether ^{99m}Tc thyroid uptake (^{99m}TcU) may be used in place of ^{131}IU for implementing personalized treatments. A retrospective study of 152 benign thyroid disease ^{131}I treatments was carried out during 2012–2020; 117 treatments were for female patients while 35 were for male patients diagnosed with either Grave's disease, multinodular goitre or toxic nodules. A statistically significant correlation was found between ^{131}IU and ^{99m}TcU data, with the data more correlated for male than female patients ($r = 0.71$ vs 0.38, p-value < 0.001). Patient age and time difference between the two respective uptake measurements significantly influenced the uptake correlation in females but not for the male cohort, although there was no significant difference between the parameters across gender. Thyroid diagnosis and hormone levels showed a significant correlation with uptakes in both genders. Estimating ^{131}IU based on ^{99m}TcU was shown to be predictive for male but not in female patients ($R^2 = 91\%$ vs 16%) (Al-Jabri, A., Cooke, J., Cournane, S., et. al., 2020).

Macauley, M., Shawgi, M., Ali, T., et. al., described about the normal reference values for thyroid uptake of Tc-99m (^{99m}Tc) pertechnetate in a UK population. A retrospective review of 60 euthyroid patients who underwent

thyroid imaging with ^{99m}Tc pertechnetate between January 2012 to April 2014 as part of dual-tracer subtraction parathyroid scintigraphy. ^{99m}Tc pertechnetate thyroid uptake values were determined for each patient. Medical records and biochemical thyroid function tests were reviewed to ensure that all patients were not on medication that could affect thyroid function and they were both clinically and biochemically euthyroid 6 months before and following the scan. Median and interquartile uptake range of ^{99m}Tc pertechnetate in euthyroid patients were 0.9 and 0.5–1.4%, respectively. The normal reference range in the study population was 0.2–2.0%. Thyroid uptake inversely correlated with age in females (r=−0.40, P=0.04), males (r=−0.50, P=0.04), and whole group (r=−0.40, P=0.002). The calculated normal reference range in this study was found to be less than that used in our own and many other UK institutions. The results demonstrate the importance of periodic evaluation of normal uptake values and provide support for prospective studies defining the normal reference range to be performed (Macauley, M., Shawgi, M., Ali, T., et. al., 2018).

Alswat, K., Assiri, S. A., Althaqafi, R. M. M., et. al., described about the thyroid uptake scans and ultrasonography provide an accurate diagnosis of hyperthyroidism, especially when thyroid receptor antibody (TRAB) measurement is not readily available. This study explored the prevalence of various hyperthyroidism causes using retrospective scintigraphy results and evaluated their relationship with clinical, biochemical, and sonographic imaging parameters from patients who underwent ^{99m}Tc-pertechnetate thyroid scans between 2016 and 2019 in Taif, Saudi Arabia, where literature is insufficient. Furthermore, the inappropriate use of thyroid scanning in different thyroid diseases was evaluated. The study enrolled 207 patients (mean age: 42.5 ± 14.7 years). The mean free T4, T3, anti thyroid peroxides antibody, anti thyroglobulin antibody, C-reactive protein, and erythrocyte sedimentation rate levels were high. Graves' disease was the most common diagnosis. Compared to toxic solitary/multinodular goiter, patients with Graves' disease were usually younger, used carbimazole during both the uptake and the scan, had an enlarged thyroid gland, and had higher FT4 and FT3 levels. Inappropriate thyroid uptake and scan use was reported in approximately 10% of patients and 25% of the patients used carbimazole during the uptake and scan. Thus, better patient education is needed to avoid misinterpreting the scan results (Alswat, K., Assiri, S.A., Althaqafi, R.M.M. et. al., 2020).

Iranpour, R., Hashemipour, M., et. al., described about the Tc-99m thyroid scintigraphy incongenital hypothyroidism screening program. The etiology of congenital hypothyroidism (CH) may be important in determining disease severity, outcome and treatment schedules because hypothyroid patients need higher treatment doses and close monitoring particularly early in life. The aim of this study was to evaluate thyroid scintigraphy (TS) findings in infants with CH and to determine the relationship of serum TSH and T4 values with thyroid agenesis, in an attempt to identify factors that may detect thyroid agenesis before treatment. Since August 2002 to April 2005, screening program for CH was carried out in the Isfahan University of Medical Sciences and Health Services, Isfahan, Iran. Screening was performed by measuring both the serums T4 and TSH concentration at day 3-7 of birth. We conclude that Tc-99m TS is a useful diagnostic tool for the initial investigation of suspected CH and considering the correlation of TS results with blood TSH levels, proper management and close monitoring of hypothyroid infants with severe hormonal alterations is necessary for the detection of thyroid agenesis (Iranpour, Hashemipour, et. al., 2006).

Reiners, C., Luster, M., et. al., explained about the radioiodine therapy in differentiated thyroid cancer. Radioiodine thyroid remnant ablation can be defined as the postsurgical therapeutic administration of I-131 to patients with differentiated thyroid carcinoma (DTC) with the primary goal of eliminating residual thyroid tissue following thyroidectomy. As a gamma and beta-ray-emitter with a physical half-life of 8.1 days, radioiodine [iodine-131 (I-131)] is also suitable for post therapeutic imaging. In most centers, standard fixed activities between 1-3GBq are commonly used for I-131 ablation. The advantages of recombinant TSH are avoidance of morbidity associated with clinical hypothyroidism and a maintained quality of life, as well as a lower radiation dose to the remainder of the body, e.g. the bone marrow. In case of distant metastatic spread, higher activities of radioiodine in the range of 4-11GBq are generally accepted; if feasible, individuall "patient specific" dosimetry should be considered. They suggest that, standard preparation approach for I-131 therapy in patients with metastases is endogenous hypothyroidism after thyroid hormone withdrawal (Reiners, Luster et. al., 2008).

Katagiri M., Suzuki S. et. al., described about the accumulation of iodine-131 and technetium-99m pertechnetate in thyroid carcinoma. Carcinoma of the thyroid is usually delineated as a cold defect on images with radioiodine and Tc-99m pertechnetate. However, several cases that showed an accumulation of Tc-99m pertechnetate in

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thyroid carcinoma or in their metastases, but did not show any accumulation of radioiodine, have been reported. This paper presents a rare case of an advanced follicular adenocarcinoma of the thyroid that accumulated both Tc-99m pertechnetate and I-131. On images with both I-131 and Tc-99m pertechnetate, the tumor in the left lobe and the metastatic lymph node were delineated, but the tumor in the right lobe was not. Accumulation of Tc-99m pertechnetate in the lower part of the tumor of the left lobe was more distinct than that of I-131. Therefore, it is considered that despite similar histologic findings the trapping ability of cancerous tissue differed from area to area (Katagiri, Suzuki et. al., 1999).

Stasiolek Mariusz explained about the neurological symptoms and signs in thyroid disease. Numerous complex regulatory mechanisms influence the development and function of the peripheral and central nervous system. Among them, hormones belong to the most potent regulatory factors. Various particles known for their hormonal activity serve as neurotransmitters. Thyroid function has been shown to play a crucial role in the proper cognitive development but also in many other aspects of nervous system activity, in mechanisms involving direct interaction with intrinsic regulatory circuits or indirectly by systemic effects exerted e.g. on the circulatory system or metabolic pathways. Due to these close relations with the nervous system function, disturbances of thyrometabolic state are associated with a vast spectrum of neurological signs and symptoms including: mood and cognitive disorders, headache, ophthalmoplegia, tremor and other movement disorders, muscle weakness etc. The severe decompensated hypothyroidism may result in myxedemacoma - a life-threatening condition with sequentially progressing encephalopathy symptoms. Steroid-responsive encephalopathy associated with autoimmune thyroiditis (SREAAT) represents another form of encephalopathy disorder associated with thyroid disease and causing potentially serious clinical complications. Such conditions have to always be taken in consideration as differential diagnoses in patients presenting with neurological signs and symptoms associated with thyroid disease (Stasiolek, 2015).

Stasiak Magdalena analyzed about diabetes and the thyroid. Thyroid disorders are more common in diabetic patients than in the general population. Abnormal thyroid function can be found in as many as 11% to 30% of patients with diabetes mellitus (DM) type 1 or 2. According to these recommendations, concentrations of thyrotropin (TSH) and thyroid peroxides antibodies (TPOAB) should be measured in every patient with newly diagnosed DM1, and in all patients with DM1 who have never undergone thyroid function tests. In exactly the same situations, patients with DM2 require TSH assessment, while TPOAB titer should be measured only if TSH reaches ≥ 2.0 mIU/L in diabetic patients be paid to women who are pregnant or planning pregnancy. In the preconception period, TSH concentration should be measured in every woman with DM, and in DM1 patients together with TPOAB level. When pregnancy is confirmed, assessment of TSH and TPOAB is advised at the first obstetrician appointment (before 9th week of pregnancy). In all pregnant diabetic patients with a past medical history of Graves' disease, anti-TSH receptor antibodies (TRAB) should be additionally measured at the first obstetrician appointment and repeated at the end of the second trimester (before the 22 nd week of pregnancy). In diabetic patients, also the hypothyroidism is proven to be an independent risk factor for cardiovascular episodes. Therefore, treatment of subclinical hypothyroidism is strongly recommended in this condition (Stasiak, 2015).

Objectives of this Study

Thyroid uptake using Tc-99m has proven to be more advantageous than with I-131 because of a number of advantages, such as a short half-life (6 hours), short retention in the gland, and no beta radiation, thus providing low dosimetry to the thyroid gland (10,000 times less than that of I-131) 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. On the other hand, Studies with I-131 have the serious disadvantage of high radiation doses to the gland (1-3 rad/mCi administered) caused by its long half-life (8 days) and beta 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.

Hence, the substantial objectives are

1. to make a comparison between Tc-99m and I-131 for performing thyroid uptake both hypothyroid and euthyroid patients.

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2. to make a correlation between Tc-99m and I-131.
3. to standardize a simple and fast method for performing thyroid uptake.

METHODOLOGY

In this work, the study consists of 87 patients, 58 females and 29 males with ages ranging from 14 to 75 years (mean of 39.2 years).

Instrumentation

The thyroid scan and thyroid uptake may be performed on the same day depending on what examination the patient requires. Different imaging equipment is used in different procedures. Thyroid scans are usually performed using a gamma camera, and the uptake measurement can be obtained with a non-imaging gamma probe (Saha, 2006).

Figure-1: Thyroid uptake probe machine (left) & Gamma camera(right) [Picture taken at research site]

Radioactive Iodine Uptake Test

The Iodine dose is typically 0.15–0.37 MBq (4–10 μCi) of I-131 sodium iodide, or 3.7–7.4 MBq (100–200 μCi) of I-123 sodium iodide. In this study I-131 was used for thyroid uptake. The normal uptake is between 4-10% at 2 hours and 10-30% at 24 hours, but this may be forced down if, in the meantime, the patient has eaten foods high in iodine, such as dairy products and sea food. Low uptake suggests thyroiditis, high uptake suggests Graves's disease, and unevenness in uptake suggests the presence of a nodule. Actual scanning time for each thyroid uptake is five minutes or less (Sedda, Rossi, et. al., 2015). The thyroid uptake of I-131 for each volunteer was calculated using the following formula:

$$\text{I} - 131 \text{ Uptake } \% = \frac{\text{Neck count} - \text{Thigh count}}{\text{Patient syringe} - \text{Empty patient syringe}} \times \frac{1}{\text{CF}} \times 100\%$$

$$\text{Here, CF= calibration factor} = \frac{\text{phantom vessel} - \text{background}}{\text{standard syringe} - \text{empty syringe}}$$

Calculation and Processing System of Tc-99m

Thyroid scintigraphy and uptake were performed twenty minutes after an intravenous injection of 370 MBq (10 mCi) of 99mTc-pertechnetate. The methods used for the calculation of thyroid uptake of Tc-99m uptake are based on thyroid gland image, full syringe counts before radiopharmaceutical injection and empty syringe counts post injection. The total number of counts was determined by an irregular region of interest drawn around the boarders of the thyroid gland tracking the thyroid gland as close as possible (TH) see figure-2 (Ramos et. al., 2002).

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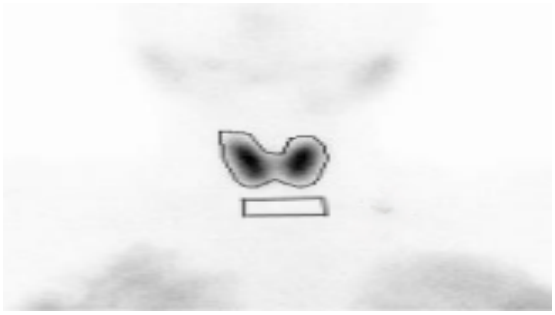

Figure-2: Irregular ROI around the thyroid gland & rectangular ROI under the thyroid gland

Another rectangular region of interest was drawn under the thyroid gland region of interest with a width approximately equal to the gland and representing the background (BK). The full syringe counts (F) before injection and empty syringe counts (E) after injection are obtained from the images. All the counts obtained were corrected for the decay of Technetium-99m pertechnetate and acquisition time (Maisey, Natarajan et. al., 1973). The thyroid uptake of Technetium-99m pertechnetate for each volunteer was calculated using the following formula:

$$\text{Tc-99m Uptake \%} = \frac{\text{TH} - \text{BK}}{\text{F} - \text{E}} \times 100\%$$

Where, TH = the total thyroid counts, BK =the total background counts,

F = full syringe counts (pre. injection counts), E =empty syringe counts (post injection counts)

The average time taken to process two volunteers was 30 minutes.

Table-1: Experimental data for Thyroid Uptake

SL NO.	REG	SEX	AGE	PRE	POST	TH	BK	UP	I-131
1	01/055	M	42	516917	16079	2103	283	3.6	2h=9% 24h=14%
2	02/010	F	35	304543	50203	14110	783	5.2	2h=30% 24h=45% 48h=43%
3	15/033	F	40	401172	11762	4618	1327	0.85	2h=9% 24=7%
4	20/085	F	17	465586	19312	11016	336	2.4	2h=19% 24h=29%
5	16/038	M	38	382116	38880	28495	682	8.1	2h=24% 24h=81%
6	04/033	F	43	579758	26895	3935	310	0.66	2h=12% 24h=18%
7	01/115	F	55	481481	23021	9709	991	1.9	2h=8%

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									24h=20%
8	08/046	F	28	484979	33439	3704	694	0.7	2h=11% 24h=13%
9	08/081	F	62	525681	24196	9965	700	1.8	2h=16% 24h=32% 48h=31%
10	08/139	F	50	504514	46319	4971	498	0.97	2h=15% 24h=30% 48h=30%
11	10/047	F	25	554772	51709	9885	175	2.0	2h=17% 24h=18%
12	10/045	F	16	493427	19182	5860	328	1.2	24h=13%
13	11/113	F	45	508547	42473	30670	1008	6.4	2h=34% 24h=62%
14	11/027	F	35	597968	37411	4888	728	0.75	2h=10% 24h=8%
15	15/009	F	33	345585	11200	11103	738	3.1	2h=12% 24h=26%
16	15/040	F	38	331623	11233	6949	563	2.0	2h=13% 24h=17%
17	15/069	M	35	243738	10848	20104	1165	8.1	2h=53% 24h=73% 48h=69%
18	09/060	F	42	256443	23295	4497	720	1.6	2h=7% 24h=12%
19	03/087	F	31	493283	38009	9387	3247	1.3	2h=12% 24h=18%
20	17/044	F	53	457876	10924	11383	1026	2.3	2h=11% 24h=19%
21	26/041	M	48	563503	47397	27713	1014	5.2	2h=29% 24h=47%

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									48h=52%
22	26/015	F	26	547993	48382	26791	1414	5.1	2h=42% 24h=65% 48h=62%
23	26/113	M	41	520656	49382	41185	1117	8.5	2h=61% 24h=67% 48h=68%
24	27/132	M	56	504487	5197	26448	1143	5.1	2h=22% 24h=45% 48h=46%
25	10/034	F	55	313557	29135	49937	1005	17.2	2h=44% 24h=62% 48h=67%
26	10/084	F	55	324027	37520	49968	611	17.2	2h=38% 24h=49% 48h=65%
27	07/036	M	60	552505	23689	4213	1153	0.58	2h=7% 24h=4%
28	02/021	M	40	533702	25337	7472	810	1.31	2h=9% 24h=16%
29	14/075	F	20	503807	27553	2643	1213	0.30	2h=8% 24h=1%
30	14/039	F	50	514771	26382	4401	850	0.73	2h=8% 24h=2%
31	13/076	M	22	533849	32984	4093	1321	0.55	2h=6% 24h=2%
32	13/088	M	16	593494	32459	3926	706	0.57	2h=9% 24h=5%
33	13/033	F	50	601368	32299	31548	741	5.4	2h=21% 24h=23%
34	15/026	F	47	421386	12773	7347	875	1.6	2h=11%

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									24h=14%
35	14/041	F	17	365796	27235	7013	664	1.9	2h=14% 24h=24%
36	21/046	F	42	558222	24138	24081	2123	4.1	2h=20% 24h=40%
37	15/147	M	45	390373	13705	6372	1279	1.4	2h=7% 24h=9%
38	12/083	F	47	514529	37706	3940	1211	0.57	2h=10% 24h=39% 48h=41%
39	05/037	M	20	456912	18905	1858	58	0.4	2h=10% 24h=6%
40	13/122	F	53	582738	52730	29866	704	5.5	2h=21% 24h=35%
41	27/081	M	41	602218	56548	7573	616	1.3	2h=8% 24h=15%
42	06/036	M	45	480059	18703	3208	400	0.6	2h=21% 24h=31% 48h=32%
43	04/013	F	27	207893	32599	7161	652	3.7	24h=29%
44	04/025	F	50	523661	23004	28303	475	5.56	24h=42%
45	12/019	M	26	500331	24414	38697	373	8.05	24h=29%
46	12/085	F	52	518319	28129	5428	429	1.02	24h=18%
47	13/112	F	22	538261	42348	40403	602	8.0	24h=31%
48	13/082	F	51	517837	40641	7075	473	1.38	24h=19%
49	19/059	F	42	617608	140253	43986	493	9.11	24h=31.7%
50	26/046	F	21	503395	60254	11206	394	2.44	24h=40%
51	05/008	F	56	256094	48725	17116	362	8.1	24h=45%
52	17/019	M	45	500603	13384	9111	1025	1.7	2h=13% 24h=34%
53	18/019	F	25	393004	12180	5613	553	1.3	2h=13%

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									24h=16%
54	29/100	M	32	671718	28206	11133	1793	1.5	2h=20% 24h=43%
55	01/101	F	54	434436	36422	33942	377	8.4	2h=18% 24h=72%
56	02/45	F	75	649867	32557	8935	1353	1.2	2h=11% 24h=20%
57	06/034	F	66	476512	25299	37561	1212	8.0	2h=54% 24h=77% 48h=81%
58	07/037	F	26	513183	25253	24423	700	4.9	2h=33% 24h=53% 48h=48%
59	08/082	M	25	501732	22428	52222	725	10.7	2h=54% 24h=69% 48h=72%
60	17/097	M	40	533231	24429	39052	510	7.6	2h=31% 24h=49% 48h=52%
61	08/027	F	37	445585	10297	5956	269	1.3	2h=8% 24h=12%
62	10/068	M	17	705165	25000	28820	1173	4.1	2h=36% 24h=42% 48h=66%
63	08/093	F	50	479838	66934	18295	875	4.2	2h=14% 24h=35% 48h=36%
64	14/052	M	35	206710	10137	40108	534	10.2	2h=32% 24h=38%
65	08/035	M	55	315155	20099	22848	627	7.5	2h=29% 24h=59%

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									48h=52%
66	06/130	F	50	247406	33481	33498	389	15.5	24h=61%
67	04/011	F	35	249187	26195	2529	920	0.72	24h=3%
68	05/055	M	42	239624	39055	33733	514	16.6	24h=47.5%
69	29/034	F	40	426205	23331	22262	1841	5.3	2h=19% 24h=43% 48h=48%
70	10/097	F	31	538509	58162	3936	1256	0.56	24h=15%
71	20/046	F	32	595994	43277	40893	593	7.2	2h=34% 24h=44% 48h=59%
72	10/083	F	32	543269	60255	5040	127	1.02	24h=13%
73	04/143	F	40	513743	24726	29663	756	5.9	2h=41% 24h=70% 48h=61%
74	23/009	M	45	659565	38826	496	156	0.055	24h=13%
75	23/024	F	58	658904	43294	8185	278	1.28	24h=30%
76	26/070	F	50	572421	45892	26615	801	4.9	2h=43% 24h=71% 48h=71.3%
77	23/011	M	21	653730	41791	140392	333	22.9	24h=59%
78	07/078	M	55	313755	29135	30260	733	10.4	2h=32% 24h=71% 48h=67%
79	22/016	M	50	432076	35343	21442	551	5.2	2h=15% 24h=35% 48h=39%
80	29/045	F	14	397994	20792	16112	1832	4.1	2h=21% 24h=43.5% 48h=43%
81	10/007	F	54	656419	57835	4617	312	0.72	24h=9%

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82	04/19	F	55	504302	20307	17648	1028	3.4	2h=12% 24h=30% 48h=31%
83	23/008	M	19	605657	40845	3827	730	0.55	24h=7%
84	05/023	F	34	440773	19250	13955	1156	3.0	2h=10% 24h=21%
85	04/034	F	50	497773	21371	51851	503	10.8	2h=45% 24h=50% 48h=44%
86	04/052	F	42	431353	19430	12227	1071	2.7	2h=14% 24h=35% 48h=36%
87	15/050	F	26	482178	44706	5912	198	1.3	24h=19%

RESULTS AND DISCUSSION

Data analysis

This study consisted of total 87 patients, 58 were women and 29 were man. The patients were from different place of Bangladesh with different ages ranging from 14 to 75 years (mean of 39.2 years).

Table-2 shows the average uptake values of the patients for both Tc-99m and I-131. Normal reference values for radioactive iodine are obtained 10%-30% at 24 hours and the reference values for thyroid uptake test used in Bangladesh are 0.75%-4% uptake of Tc-99m at 20 minutes. A patient with average uptake values within the range is known as euthyroid, below the range is known as hypothyroid and the above the range is known as hyperthyroid patients (Sedda, Rossi, et. al., 2015).

Table -2: The average Uptake Value

Tc-99m (Normal range is 0.75%-4%)	I-131 (Normal range is 10%-30%)
Euthyroid- 1.86% (35 patients out of 87)	Euthyroid-19.28% (32 patients out of 87)
Hypothyroid - 0.551% (15 patients out of 87)	Hypothyroid-5.25% (12 patients out of 87)

From table-2 it can be shown that out of 87 patients 35 were euthyroid, 15 patients were hypothyroid and others (37) were found hyperthyroid by using Tc-99m. The average uptake values of euthyroid patients are 1.86%, hypothyroid patients are 0.551% for Tc-99m. Similarly, out of 87 patients 32 were euthyroid, 12 patients were hypothyroid and others (43) were found hyperthyroid by using I-131. The average uptake values of euthyroid patients are 19.28%, hypothyroid patients are 5.25% for I-131.

Table-3 shows the thyroid uptake test using I-131 with euthyroid, hypothyroid and hyperthyroid patients and the relative pie chart (figure-3) are also shown here according to table-3. From this pie chart 37% were found

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euthyroid, 14% were hypothyroid and 49% were hyperthyroid patients by using I-131.

Table-3: Thyroid uptake test using I-131

Euthyroid	32
Hypothyroid	12
Hyperthyroid	43

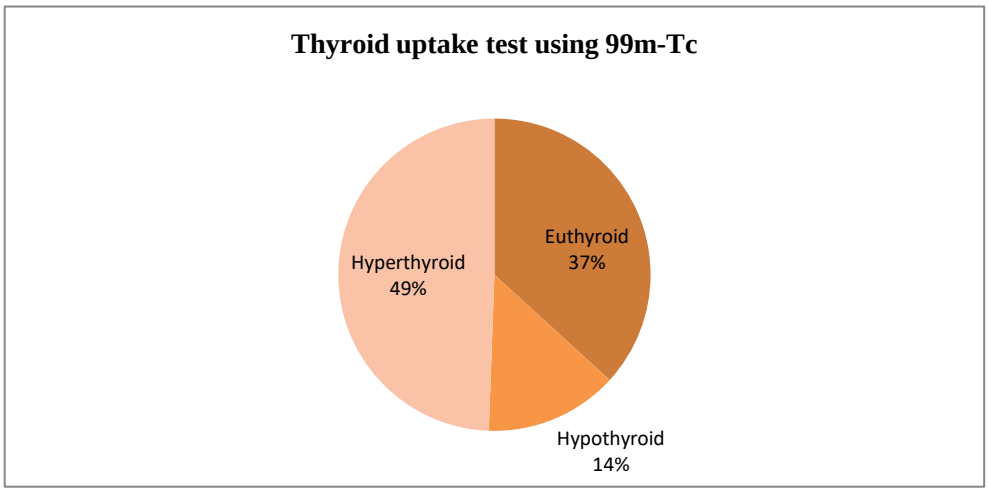

Figure-3: Pie Chart for Thyroid Uptake test using I-131 according to table-3

Table-4 shows the thyroid uptake test using Tc-99m with euthyroid, hypothyroid and hyperthyroid patients and the relative pie chart are shown in figure-4 according to table-4. From this pie chart 40% were found euthyroid, 17% were hypothyroid and 43% were hyperthyroid patients.

Table-4: Thyroid uptake test using Tc-99m

Euthyroid	35
Hypothyroid	15
Hyperthyroid	37

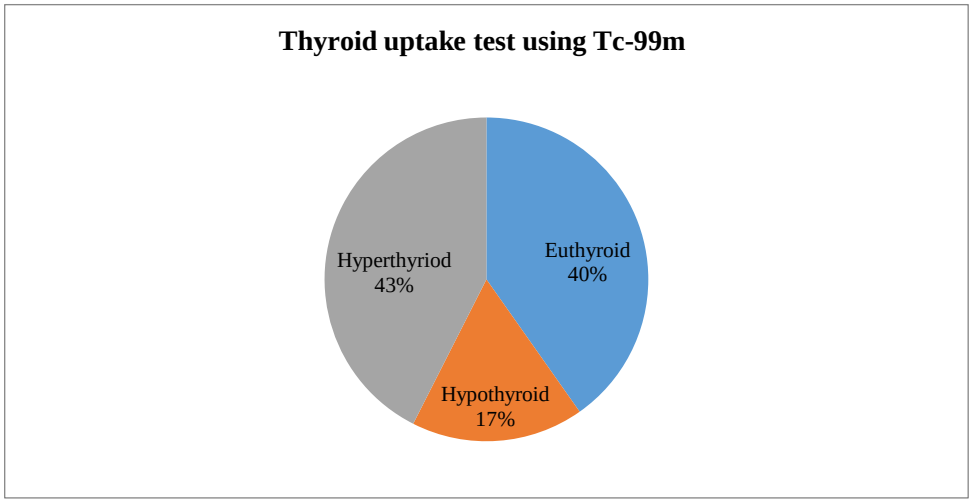

Figure-4: Pie Chart for Thyroid Uptake test using Tc-99m according to table-4

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Table-5 shows out of 87 patients 12 were found hypothyroid by using I-131. Among 12 patients 10 were positive with both I-131 and Tc-99m (true positive). Only 2 patients had positive results with I-131 and negative results with Tc-99m (false negative). Similarly, hypothyroidism was found in 15 patients out of total 87 patients using Tc-99m. Among 15 patients 10 were positive with both I-131 and Tc-99m but 5 patients were positive with Tc-99m but negative with I-131 (false positive). Considering I-131 imaging as the gold-standard procedure, Tc-99m had a good relationship of 83.33% (10 out of 12) for the detection of hypothyroidism with I-131.

Table-5: Total number of hypothyroid patients using both I-131 & Tc-99m

Individuality→ Hypothyroid patients↓	**I-131 positive & Tc-99m positive**	**I-131 positive & Tc-99m negative**	**I-131 negative & Tc-99m positive**
Total patients (12)	10	2	5
Male patients (6)	5	1	2
Female patients (6)	5	1	3

From the table-5 it also can be shown that, out of total 12 hypothyroid patients 6 male and 6 female patients were found. Among male patients 5 patients were positive with both Tc-99m and I-131 (true positive). Only one patient had negative results with Tc-99m and positive results with I-131 (false negative). 2 patients were positive with Tc-99m but negative with I-131 (false positive). The relationship between Tc-99m and I-131 for 6 male hypothyroid patients was found 83.33% (6 out of 5). Similarly, among 6 female patients 5 patients were positive with both Tc-99m and I-131 (true positive). Only one patient had negative results with Tc-99m and positive results with I-131 (false negative). 3 patients were positive with Tc-99m but negative with I-131 (false positive). The relationship between Tc-99m and I-131 for 6 female hypothyroid patients was found 83.33% (6 out of 5).

Table-6 shows out of 87 patients 32 were found euthyroid by using I-131. Among 32 patients 26 were positive with both I-131 and Tc-99m (true positive). 6 patients had positive results with I-131 and negative results with Tc-99m (false negative). Similarly, euthyroidism was found in 35 patients out of total 87 patients using Tc-99m. Among 35 patients 26 were positive with both I-131 and Tc-99m but 9 patients were positive with Tc-99m and negative with I-131 (false positive). Considering I-131 imaging as the gold-standard procedure, Tc-99m had a good relationship of 81.25% (26 out of 32) for the detection of euthyroidism with I-131.

Table-6: Total number of euthyroid patients using both I-131 & Tc-99m

Individuality→ Euthyroid patients↓	**I-131 positive & Tc-99m positive**	**I-131 positive & Tc-99m negative**	**I-131 negative & Tc-99m positive**
Total patients (32)	26	6	9
Male patients (5)	3	2	3
Female patients (27)	23	4	5

From the table-6 it also can be shown that, out of total 32 euthyroid patients 5 male and 27 female patients were found. Among male patients 3 patients were positive with both Tc-99m and I-131 (true positive). Only two patients had negative results with Tc-99m and positive results with I-131 (false negative). 3 patients were positive with Tc-99m but negative with I-131 (false positive). The relationship between Tc-99m and I-131 for 5 male euthyroid patients was found 60% (3 out of 5). Similarly, among 27 female patients 23 patients were positive with both Tc-99m and I-131 (true positive). 4 patients had negative results with Tc-99m and positive results with I-131 (false negative). 5 patients were positive with Tc-99m but negative with I-131 (false positive). The relationship between Tc-99m and I-131 for 27 female euthyroid patients was found 85.19% (23 out of 27).

Table -7 shows the total number of male and female hypothyroid patients by using both I-131 & Tc-99m.

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Table-7: The number of male & female hypothyroid patients

Patients→ Radiotracer↓	**Male Patients**	**Female Patients**
I-131	6 out of 12 patients	6 out of 12 patients
Tc-99m	7 out of 15 patients	8 out of 15 patients

Table-8 shows the total number of male and female euthyroid patients by using both I-131 & Tc-99m.

Table-8: The number of male & female euthyroid patients

Patients→ Radiotracer↓	**Male Patients**	**Female Patients**
I-131	5 out of 32 patients	27 out of 32 patients
Tc-99m	6 out of 35 patients	29 out of 35 patients

Statistical Analysis

Correlation

Pearson Correlation is the standard measure of correlation in statistics. It shows the linear relation between two sets of data. To find the relationship between variables in the data, correlation coefficient is used. Pearson correlation coefficient (r) takes values between -1 and 1, where 1 implies a good relationship that is optimistic. A clear negative relationship is indicated by -1. No relationship at all implies a consequence of zero (Turney, S. 2024).

The P value in Pearson correlation is used to measure the significance of the correlation analysis. It is a standard method to determine whether the correlation coefficient is statistically significant or not. The P value is typically set at 0.01 or 0.05. A P value less than the cutoff indicates that the correlation coefficient is statistically significant, while a P value greater than the cutoff indicates that the correlation coefficient is not statistically significant (Sil, A., Betkerur, J., et. al., 2019).

Figure-5 of scatter diagram is shown for the uptake values of the hypothyroid participants in both two methods. X-axis represents uptake values of Tc-99m while Y-axis is for represents the I-131 uptake values. The graph is drawn at maximal intersect and reveals Pearson's correlation coefficient, r to be 0.56 and p value to be 0.058.

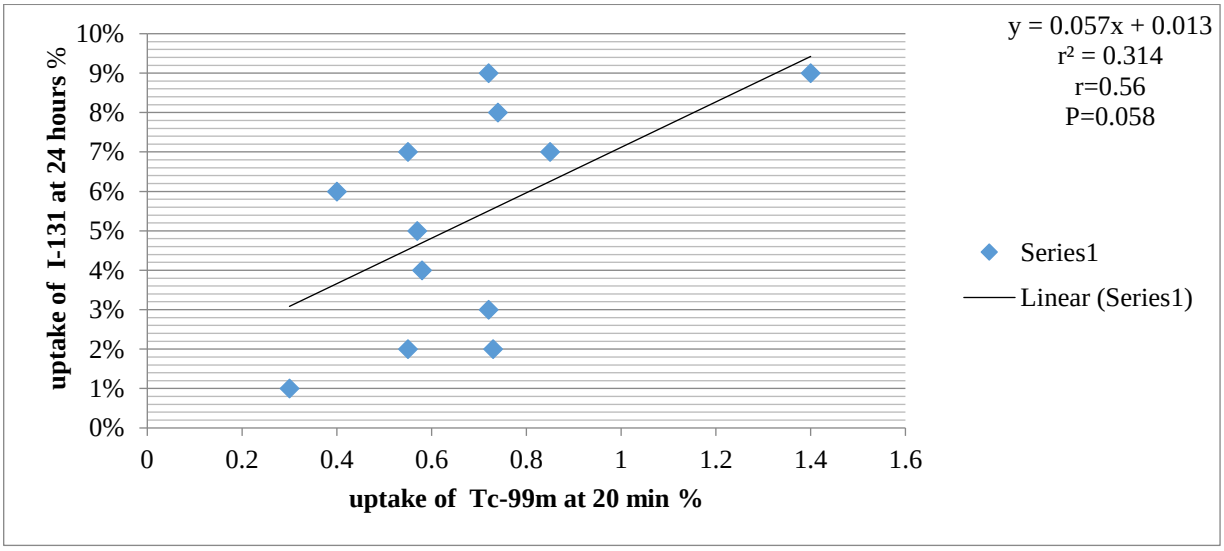

Figure-5: Scatter diagram for the uptake of Tc-99m at 20 min and I-131 at 24 hours for hypothyroid patients

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Figure-6 of scatter diagram is shown for the uptake values of the euthyroid participants in both two methods. X-axis represents uptake values of Tc-99m while Y-axis is for represents the I-131 uptake values. The graph is drawn at maximal intersect and reveals Pearson's correlation coefficient, r to be 0.49 and p value to be 0.005.

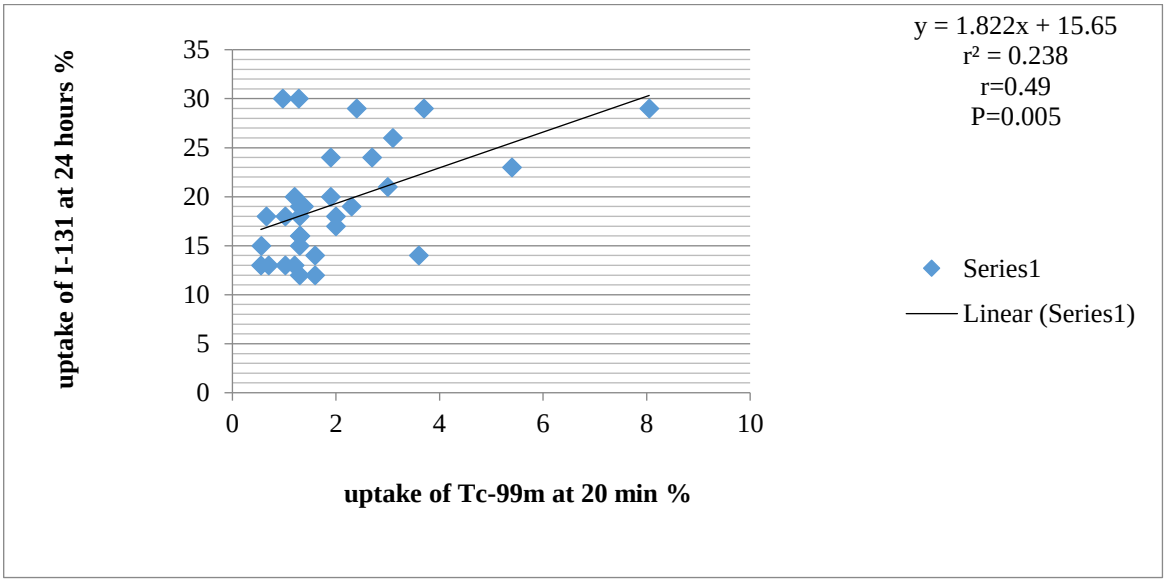

Figure-6: Scatter diagram for the uptake of Tc-99m at 20 min and I-131 at 24 hours for euthyroid patients

CONCLUSION

In the current study, a moderate agreement and a moderate positive correlation between the two uptake methods were observed. Moreover, as the sample size was small, minor variations in the result have much greater effect on overall impression. I have included total 87 patients. Comparison and correlation was made between 99m-Tc and I-131 for both hypothyroid and euthyroid patients. Good relationship could be seen in both the cases. Tc-99m had a good matching of 83.33% (10 out of 12) for the detection of hypothyroidism with I-131 where for 6 males and 6 female hypothyroid patients, matching was found 83.33% (6 out of 5). Also, for the detection of euthyroidism, Tc-99m had a good similarity of 81.25% (26 out of 32) was found with I-131 where for 5 males and 27 female euthyroid patients, similarity was found 60% (3 out of 5) and 85.19% (23 out of 27) respectively.

In statistical analysis, a statistically significant correlation was found between I-131 and Tc-99m for euthyroid patients. Pearson's correlation coefficient, r to be 0.49 which indicates moderate degree of relation and p value to be $0.005 \leq 0.05$ indicates that the correlation coefficient is statistically significant. For hypothyroid patients, Pearson's correlation coefficient, r to be 0.56 which indicates moderate degree of relation but p value to be $0.058 > 0.05$ indicates that the correlation coefficient is not statistically significant since the number of hypothyroid patients were small in amount. Further study and more patients should be included to better significant result for hypothyroid patients. Therefore, estimating thyroid uptake based on Tc-99m is not recommended for hypothyroid patients in my research study. Detection of euthyroidism by Tc-99m with I-131 reported good correlation, but a larger sample would be needed for validation.

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