

# <sup>131</sup>I Single Photon Emission Computed Tomography/Computed Tomography (SPECT/CT) versus planar gamma-camera imaging in diagnosis of metastasis for intermediate and high-risk patient with thyroid carcinoma

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**ABSTRACT** Background: SPECT/CT is a more effective instrument diagnosing as well as detecting thyroid cancer and determining treatment methods compared to a whole-body planar scan. The objective of this research is to directly compare <sup>131</sup>I SPECT/CT methods for detecting metastatic thyroid carcinoma in the high-risk and intermediate-risk group methods to assess the diagnostic precision and performance of iodine-131 body scanning (WBS) with or without SPECT/CT.

**Patient and Methods:** Sixty thyroid carcinoma sufferers, 43 women and 17 men, ages 11 years–76 years had been diagnosed with thyroid malignancy at both the Al-Kawthar Nuclear Medicine Center in Basra and the department of Nuclear Medicine at Al-Andalus Private Hospital in Baghdad. Each patient had a full or almost full thyroid surgery. Patients were divided into two groups: thyroid tumors that have an intermediate-risk and high risk. They were administered dose therapy with radioactive iodine-131 of (3.7 GBq [100 mci]) to (7.4 GBq [200 mci]) and acquired a planar scan 5 days after taking the dose. Planar whole-body examination foci of uptake have been defined as lymph nodes, lung metastases, bone metastases, thyroid remnant, or of unknown cause. These regions were subsequently imaged using a dual-head gamma camera for single-photon emission computed tomography (SPECT/CT), and the categorization was changed according to the imaging. **Result:** Planar scans depicted 86 foci of <sup>131</sup>I activity, classified as 45 neck foci and 41 distal foci. The majority of radioactive iodine uptake foci are located in the lung and bone. These foci were further divided into groups of distant metastasis, metastatic lymph node lesions, physiological activity, and thyroid remnants on SPECT/CT. 4 (7%) of the 39 foci were correctly downgraded from equivocal thyroid remnant to thyroid remnant by SPECT/CT findings, while 16 (27%) of the 39 foci were correctly downgraded from equivocal or thyroid bed remnant. More than two (3%) of the 39 foci were classified as physiological activity or salivary activity. SPECT/CT corrected 2 (3%) of the original 39 foci that were judged to be equivocal in the lymph nodes, and of these, 23 (38%) were correctly identified. The final classification included 2 physiologic activities, 17 metastatic lung lesions, and 11 metastatic bone lesions. However, in cases of bone metastases, additional properties could be achieved with SPECT/CT anatomical localization for iodine activity. **Conclusion** The present investigation employed SPECT/CT for ultra-fast detection of metastatic tumors with metastatic spread, screening, and efficient verification based on physiological simulation of the disease. Modification of therapeutic strategies in 26 (43%) intermediate-risk patients to high-risk patients of thyroid cancer through precise localization and characterization of iodine-131 avid foci <sup>131</sup>I SPECT/CT shows greater value

than <sup>131</sup>I planar Whole-Body (WBS) in treatment management, in addition to being helpful for determining the radioiodine therapy dosage and for directing the surgical procedure.

**Keywords:** SPECT/CT, radioactive iodine-131, thyroid carcinoma, planar whole-body scan, hotspot locations

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## INTRODUCTION

Thyroid carcinoma, the most prevalent kind of endocrine cancer, which accounts for 1% of all malignancies diagnosed each year, affects women 2-3 times more frequently than males [1].

Thyroid cancer is divided according to histology into four malignancies: medullary, papillary, follicular, and anaplastic types of thyroid carcinoma. The majority of thyroid cancers are papillary, which is the most typical kind, followed by follicular cancer, these types characterized by its uptake of radioactive iodine -131 [2].

Most patients who undergo primary thyroidectomy also undergo excision of the thyroid residual by <sup>131</sup>I. Patients with metastatic illness had better prognoses after receiving <sup>131</sup>I therapy for local and distant metastases [3].

For planning therapy and follow-up, a precise identification of the lymphatic nodes in the cervical region and metastases is essential. A significant predictive factor is the degree of far-off metastases or local cervical lymph disease [4].

Since all patients with Lymph Node Metastases (LNM) are considered to be high-risk, the presence or absence of LNM is a critical factor [5].

Following thyroidectomy, planar <sup>131</sup>I (WBS) blood thyroid hormone values are considered to be the standard diagnostic method for individuals with thyroid carcinoma [6].

As a way to stage thyroid carcinoma patients, <sup>131</sup>I planar imaging incorporates morphologic imaging techniques such as ultrasound, Computed Tomography (CT), and Magnetic Resonance Imaging (MRI). The shortcomings of this technique are due to normal uptake rather than pathologic uptake, the over imposition of various anatomical structures, the lack of trustworthy anatomical references, and other factors [7].

In order to accurately match anatomical and functional data, a combination of SPECT and CT utilizing <sup>131</sup>I delivers physiological and anatomic information. Many investigations have looked into the further examination of the benefits of SPECT/CT in the treatment of thyroid cancer patients [8, 9].

This study's goal turned out to be to review how the additional evaluation of iodine-131 SPECT/CT vs. a scintigraphy whole-body within resolving equivocal results in a sizable. Additionally, it was looked at how well SPECT/CT evaluated and planned treatment for intermediate-risk and high-risk thyroid cancer patients.

## MATERIAL AND METHOD

This is a cross-sectional clinical study from November 2022 to May 2023, selecting 60 patients 43 women and 17 men, between the ages of 11 and 76, who had been diagnosed with thyroid cancer. As they all underwent total or nearly total thyroidectomy between 1999 and 2023. They were received at the Al-Andalus Private Hospital's Nuclear Medicine Section in

Baghdad and at the Al-Kawthar Nuclear Medicine Center in Basra. All patients with diagnosed thyroid cancer histologically (54 papillary carcinomas, 4 follicular carcinomas, and 2 Hurthle thyroid carcinomas) who participated in this study were treated with Radioactive Iodine (RAI) 30 days after surgery, received <sup>131</sup>I treatment, and had nodules in the thyroid bed on ultrasound imaging for postoperative monitoring.

Patients belonging to groups classified as high and moderate risk were enrolled before the iodine dose was administered. Patient records were used to collect information on clinical criteria (age, gender, type of surgery) and pathological data (tumor size, pathologic stage, lymph node metastasis (mLN) number, distant Metastasis (Mx), pathologic TNM classification (tumor, node, metastasis) stage, Thyroid Stimulated Hormone (TSH), Thyroglobulin (Tg), and anti-thyroglobulin (anti-Tg) before iodine therapy. Before receiving iodine-131 (a sodium iodide capsule), for three weeks, each patient had a low-iodine meal. ahead of delivering the prescribed dosage of the therapeutic dose of <sup>131</sup>I-iodine. Administered doses of iodine-131 ranging to 3.7 GBq [100 mci] for 4.4 GBq [120 mci] and 5.5 GBq [150 mci] for intermediate-risk persons and a high dosage of 6.47 GBq [175 mci], 6.66 GBq [180 mci], and 7.4 GBq [200 mci] for high-risk patients. Planar Whole body imaging and single-photon emission computed tomography/computed tomography examinations from the device type (a General Electric GE, Model: Discovery 670 NM/CT) for all patients were performed on the same day, 5 days–7 days after iodine-131 administration. It consists of a multidetector (16-row) helical CT (NM670 GE) and a dual-head gamma camera with sodium iodide crystals that are 1.5 cm in diameter. Over 360 CT images were collected in 14 seconds per slice across the axis. Multiple views of 360 SPECT images were obtained in a 128×128 matrix with an angular step of 6 and an acquisition time of 30 seconds per view. Results from planar images were used to determine the SPECT/CT field of view. A parallel-hole collimator with high energy was employed (364 keV). A Xeleris workstation (NM670; General Electric GE Discovery Medical Systems, Milwaukee, GE Healthcare) reconstructed and merged the SPECT and CT images, where the planar imaging and SPECT/CT data had been reconstructed.

### Inclusion criteria

- All individuals with high-risk and intermediate-risk thyroid carcinoma who were diagnosed histologically.
- This study included patients treated with radioactive iodine after full or nearly full thyroidectomy

### Exclusion criteria

- Pregnant women and Breastfeeding.

### Image and data analysis

All images from planar imaging and SPECT/CT had been examined independently by two qualified nuclear medicine doctors. First, the absorption foci were discovered, which were later categorized as thyroid remains after being determined to be localized in the thyroid fundus. Foci that were laterally positioned in the neck and clearly distinct from the medial section were classified as positive for thyroid bed uptake, while those that were close to the medial portion were evaluated as equivocal. The results of <sup>131</sup>I SPECT/CT were contrasted with those of planar imaging acquired with a Xeleris workstation-specific. The findings describe that local iodine uptake at physiological locations, such as the salivary glands, gastrointestinal tract, or bladder, is normal and suggests physiologic uptake, whereas localization to soft tissue organs, skeletons, or lymphatic nodes (as well as the intestines and urinary system) is considered malignant. Equivocal Lymph Node metastasis (mLN) was defined as a location, placement hadn't been determined among the pulmonary tissue and the middle part of the pulmonary or thyroid remnant. When it was obvious that a radioactive buildup in the stomach or intestines was not the cause, radioactive foci that were situated from the neck down and outside the two lung fields were labeled as positive for absorption in distant metastases. In every situation, concentrated iodine uptake was compared with SPECT/CT results and declared positive when it was comparable to small lung nodules or degenerating bony lesions. Data were examined for all thyroid cancer patients and then for two groups treated

with iodine-131 after surgery. For each patient, the thyroid gland, cervical lymphatic nodes, distal locations in the liver, the upper body, and bone were examined, as well as the <sup>131</sup>I focal absorbance on planar images, or SPECT/CT. SPECT/CT scans were used to evaluate the CT findings.

### Statistical analysis

The Statistical Packages for Social Sciences, version 22, statistical package it was employed to examine the information. (SPSS-22).

## RESULTS AND DISCUSSION

Through this study, we examined the diagnostic value of single photon emission computed tomography and computed tomography versus whole body scintigraphy for 60 patients (43 females (72.88%) and 17 males (27.12%) with a mean age of 45.85 years  $\pm$  12.62 years, and the female patient numbers were higher than the male ones overall. Each patient had a full or nearly full thyroid surgery for locally advanced or metastatic disease. Clinical and pathological information was taken from patients' detailed records before radioactive iodine administration and before imaging, as shown in Table 1. This table details the information for each patient diagnosed with thyroid cancer in terms of gender, age, Thyroid Stimulated Hormone (TSH) value, as well as the dose of radioactive <sup>131</sup>I that was administered.

Tab. 1. Patients characteristics (n=60)	Characteristics of patients		Statistic
	Age (Years)	Mean $\pm$ SD	
TSH mU/L	Mean $\pm$ SD		68.99 $\pm$ 23.93
Tumor Size (cm)	Mean $\pm$ SD		2.97 $\pm$ 1.90
Gender	Female		43 (72.88 %)
	Male		17 (27.12%)
Histologic type	Papillary		91.67%
	Hurthle cell		5%
	Follicular		3.33%
Original region of the body	Neck		47.19%
	Chest and Abdomen		23.60%
	Pelvis		12.36%
	Equivocal		10.11%
	Bone Metastasis		6.74%
Therapeutic dose (mCi)	100		38.33%
	120		43.33%
	150		3.33%
	175		6.67%
	180		1.67%
	200		6.67%

Thyroid Stimulated Hormone (TSH) level varies greatly between patients, and it is the most important test done by the patient before ingesting the dose. The patients had average TSH levels (68.99 mIU/L), with a range of 107 mIU/L. Those with results tested for the highest TSH level (115 mIU/L) and the lowest TSH level [9 mIU /L] for each patient The histologic type is also different between patients; the more prevalent kind of thyroid cancer in this study was (PTC) papillary thyroid cancer (91.67%), as opposed to individuals with follicular carcinoma (5%) and Hurthel cell (3.33%) . According to the recommendations of the American Thyroid Association (ATA) in 2015, Participants in the present

research were split into two distinct sets: intermediate-risk patients and high-risk patients. The number of patients in this study was 14 (23%) intermediate-risk patients and 46 (77%) patients with high risk, and they were given a dose of radioactive iodine, which the specialist doctor prescribed to them according to their condition. Radioactive iodine was administered orally, and the dose of iodine administered to patients was [100 mci (3.7 GBq)] (38.13%), [120 mci (4.44 GBq)] (43.33%), [150 mci (5.55 GBq)] (3.33%), [175 mci (6.4 GBq)] (6.67%), and [200 mci (7.4 GBq)] (6.67%), as shown in Figure 1.

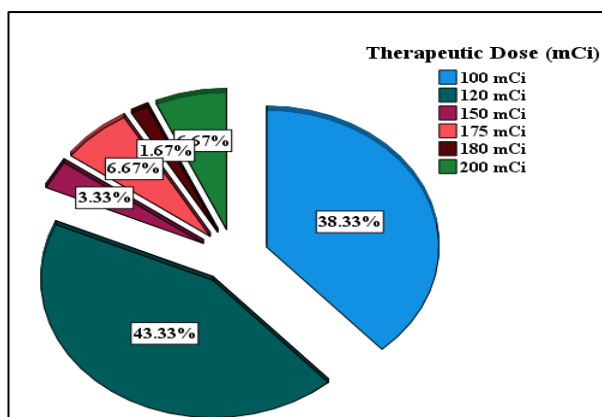


Fig. 1. The distribution of thyroid carcinoma patients' therapeutic dose (mCi)

Data on regional and distant metastatic status after iodine<sup>131</sup> scanning and the impact of imaging findings on American Thyroid Association (ATA) risk stratification are summarized in Table 2. In this study of thyroid cancer patients, intermediate and high-risk iodine-starved regional metastases were seen in 14/46 patients (30%) and distant metastases (M) in 19/41 patients (46%), according to Radio-Active Iodine uptake (RAI) <sup>131</sup>I. The final ATA

risk categories that were determined after examining the data from the iodine-<sup>131</sup> screening are as follows: 0/14 points are considered intermediate-risk, and 5/46 points are considered high-risk. As resolution was evaluated, unexpected distant and local metastases were found, resulting in the ATA risk classification being changed to the high-risk category.

Parameters	Intermediate Risk	High Risk	p-value
Age	43.71 ± 12.50	46.50 ± 12.72	0.474
Number of Patients	14 (23%)	46 (77%)	< 0.001*
TSH mU/L	67.19 ± 6.78	69.54 ± 3.50	0.0175*
Tumor Size (cm)	2.34 ± 0.51	3.13 ± 0.27	0.0235*
Tumor classification (T1/T2/T3)	09-05-2000	11/26/9	< 0.001*
N stage (Nx or N0/N1a/N1b)	11-03-2000	3/31/12	< 0.001*
Metastasis Mx or Mo/M1	14/0	May-41	< 0.001*
Administered RAI activity (mCi) (100/120/150/175/180/200)	9/3/2/0/0/0	14/23/0/4/1/4	< 0.001*
RAI Times (once/Twice/Three/Four)	12/2/0/0	30/11/3/2	< 0.001*

\* Significant difference at a value equal to or less than 0.05.  
 \*RAI: Radio-Active Iodine, N: refer of lymph node.

The table also summarizes the evaluation of TNM classification by stage (tumor, node, and metastasis). Clinical staging using the TNM classification, in addition to the data from the SPECT/CT scan, is more widely used for thyroid carcinoma. This table also shows the assessment of thyroid carcinoma patients between moderate-risk and high-risk. High-risk persons had more patients than intermediate-risk patients, with no significant difference. The

TNM system depends on determining the volume of the cancer (T) and whether or not one is present. How far the cancer has spread to the Lymph Nodes (LN) and whether the cancer has metastases outside the lymph nodes (mLN) The tumor size T for patients at intermediate risk was [2.34 cm ± 0.51 cm], while the tumor size for patients at high risk was (3.13 cm ± 0.27 cm), and the p value among them was (0.0235). Planar scans depicted 86

foci of <sup>131</sup>I activity, classified as 45 neck foci and 41 distal foci. The majority of radioactive iodine uptake foci are located in the lung and bone, as shown in Table 3. These foci were further divided into groups of distant metastasis, metastatic lymph node lesions, physiological activity, and thyroid remnants on SPECT/CT. 16 (27%) of the 39 foci were correctly downgraded from equivocal thyroid remnant to thyroid remnant by SPECT/CT findings. More than two (3%) of the 39 foci were classified as physiological activity or salivary activity. SPECT/CT corrected 2 (3%) of the original 39 foci that were judged to be equivocal in the lymph nodes, and of these, 23 (38%) were correctly identified. The final classification included 2 physiologic activities, 17 metastatic lung lesions, and 11 metastatic bone lesions. However, in cases of bone

metastases, SPECT/CT has allowed more anatomical localization of iodine activity. Therefore, for a total of 62 of the 86 iodine-<sup>131</sup> foci (72%), SPECT/CT's additional benefits in comparison to a whole-body scan were identified in 45 of the 86 tumors in the middle of the neck (52.3%) and in 15 of the 19 far-off focal (78.9%) of the thyroid cancer patients.

Majority of individuals was males (64.3%; n=36), while females were 35.7% (n=20), whereas 61.3% (n=19) males and 38.7% (n=12) females diagnosed with CRC were involved. Also, 68.0% (n=17) male and 32.0% (n=8) female healthy controls were involved. According to results in figure 1, there was no significant difference between gender of CRC patients and healthy controls with p-value (<0.5).

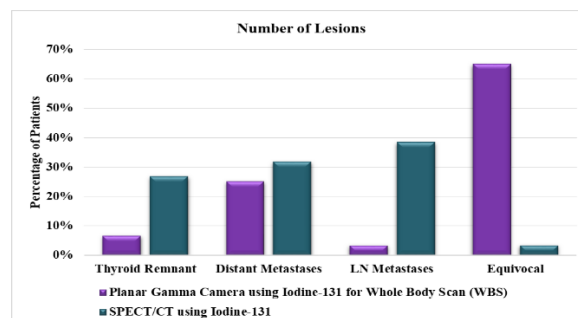
**Tab. 3.** Types of lesions detected by planar gamma camera versus SPECT/CT

Type of Lesions	Planar Gamma Camera using Iodine-131 for Whole Body Scan (WBS)	SPECT/CT using Iodine-131	p-value
Thyroid Remnant	4 (7%)	16 (27%)	0.012*
Distant Metastases	15 (25%)	19 (32%)	0.608
LN Metastases	2 (3%)	23 (38%)	<0.00*
Equivocal	39 (65%)	2 (3%)	<0.00*
p-value	<0.001*	<0.001*	-

\*Significant Difference at p-value less or equal to 0.05

In this trial, rapid, precise, and dependable evaluation of iodine activities beyond the biological distribution was possible with <sup>131</sup>I SPECT/CT, as shown in Figure 2. On SPECT/CT scans, the quantity of ambiguous focal is reduced in planar evaluation, with major cervical movement seen in residual thyroid tissue or localized regional illness. To detect distant metastatic disease and better localization of the tumor, as well as anatomical data gained via

SPECT/CT imaging, help inform clinical management decisions. SPECT with low-energy CT is also an addition to the dose of radioactive iodine and ranges from 1 to 2 mSv, but the risks associated with this are far outweighed by the advantages of hybrid imaging.



**Fig. 2.** Comparison of types of lesions detected by planar gamma camera versus SPECT/CT

This research showed that planar scanning can detect lesions in the majority of individuals and can both accurately and with more anatomical details detect lesions in the SPECT/CT. As a result, findings tend to promote the notion SPECT/CT images ought to never be recognized independently of whole-body scintigraphy.

## CONCLUSION

In conclusion, in this study, compared with planar imaging alone, <sup>131</sup>I SPECT/CT provides significantly more diagnostic data and additional benefit over whole-body planar scintigraphy for patients who received an oral therapeutic dose of <sup>131</sup>I. Also, SPECT/CT showed where the far-off

malignancies are located for screening and prompt verification of physiological simulation-related illnesses. Modification of therapeutic strategies in 26 (43%) intermediate-risk patients to high-risk patients of thyroid carcinoma through precise localization and characterization of <sup>131</sup>I avid foci. This change in the treatment of patients with thyroid carcinoma is due to the ability of SPECT/CT to overtake or bypass the disease, and <sup>131</sup>I SPECT/CT shows greater diagnostic value than <sup>131</sup>I planar Whole-Body (WBS) in treatment management, in addition to being helpful for determining the radioiodine therapy dosage and for directing the surgical procedure.

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