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Iodine-131 planar sintigraphy compared to single photon emission computed tomography/computed tomography (SPECT/CT) imaging for the detection of thyroid cancer metastases in intermediate-risk and high-risk patients

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Original Research

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Abstract:

Traditional planar iodine-131 whole-body scan (WBS), which is frequently used to find radioiodine-avid metastases in thyroid cancer patients, is regarded as the standard diagnostic method. The constraints of planar iodine-131 whole-body scan in iodine-avid metastases have been addressed using SPECT/CT. The aim of this study was to compare iodine-131 SPECT/CT in the diagnosis of metastasis intermediate- and high-risk with thyroid carcinoma by radioactive iodine as therapy versus planar imaging. In a cross-sectional study, to sixty patients with diagnosed thyroid cancer 43 women and 17 men, ages 11 – 76 years to were examined at both the nuclear medicine sections of the Al-Andalus Private Hospital in Baghdad and the Al-Kawthar Nuclear Medicine Center in Basra. All patients had full or nearly full thyroid surgery. They received dose treatment with radioactive iodine-131 ranging from 3.7 GBq (100 mci) to 7.4 GBq (200 mci), after 5 days following the dosage, they had a planar whole body scan as well as SPECT/CT for the same day. Planar whole body scan and SPECT/CT data had been interpreted very differently for lymph node metastases and distant metastases, identifying sites of iodine uptake in some patients as it was judged equivocal, especially in the neck area, where the frequency of equivocal foci and middle cervical action was classified as a locoregional or thyroid residual illness. SPECT/CT interpreted the foci of iodine uptake sites thought to be equivocal detected on planar imaging. The results of the current study showed that the interpretation of uptake foci on whole-body planar imaging changed when the SPECT/CT results were reviewed, and the treatment plan had changed in 26 (43%) of 60 patients. This change was due to dependence on iodine uptake sites in the foci. The combination of SPECT/CT images had an increased greater than iodine-131 in planar scans in accurately defining central neck activity, and the incidence of radioactive avid metastases to lymphatic nodes (LN) on SPECT/CT was unusually large. SPECT/CT showed significantly more diagnostic data and additional benefit over whole-body planar scan for patients who received an oral therapeutic dose of iodine-131.

Keywords: SPECT/CT; Whole-body planar scan; Thyroid carcinoma; Radioactive iodine

1. Introduction

Thyroid carcinoma, the most common kind of endocrine malignancy, impacts females approximately threefold more commonly compared of men and makes roughly one percent of all cancers diagnosed annually [1]. Thyroid malignancies, divided into four types, are remarkably diverse in their characteristics: medullary, papillary, follicular, and anaplastic types of thyroid carcinoma. There are significant diagnostic, therapeutic, and prognostic variations between the four cancer forms, despite the fact that they are all managed similarly [2]. The majority of patients who have an initial thyroidectomy also have the thyroid remnant also undergo excision by iodine-131.

Individuals with metastatic disease who received ^{131}I treatment for both local and distant metastases had improved prognoses [3]. For the treatment of individuals of thyroid cancer, iodine-131 planar imaging is essential. On the other hand, because to an absence of structural cues, exact localization of the iodine-131 uptake foci might be challenging. There are several more possible locations for physiologic absorption, including the liver, gastrointestinal system, the urinary tract, and salivary glands [4].

The current study aimed to compare iodine-131 SPECT/CT in the diagnosis of metastasis in patients with intermediate- and high-risk thyroid cancer using radioactive iodine as therapy versus planar imaging.

2. Patients and methods

Selecting 60 individuals with thyroid cancer for this cross-sectional clinical research from November 2022 to May 2023 were 43 women and 17 males among the ages of 11 and 76. They were therapy at the Al-Andalus Private Hospital's Nuclear Medicine department in Baghdad and at the Al-Kawthar Nuclear Medicine Center in Basra. All study participants who had malignancy of the thyroid that had been histologically confirmed (54 papillary thyroid cancer (PTC), 4 follicular thyroid cancer (FTC), and 2 Hurthle thyroid cancer (HTC)) got radioactive iodine orally (RAI) therapy 30 days after surgery. Forty-one patients were given radioactive iodine once time, thirteen patients were given treatment twice, three times three patients, and four times two patients. All patients were prevented from taking thyroid hormone for 3 weeks before receiving radioactive iodine treatment to stimulate thyroid hormone. All patients adhered to a low-iodine diet for three weeks before administering iodine-131 (a sodium iodide capsule). Prior to the therapeutic dosage of iodine-131 being given. Administered dose of 1 odine-131 to 3.7 GBq (100 mci) to 4.44 GBq (120 mci) to 5.55 GBq (150 mci), 6.47 GBq (175 mci), 6.66 GBq (180 mci), and 7.4 GBq (200 mci). Each patient received guidance and directions on what to do prior to and following receiving a therapeutic dosage of radioactive iodine-131 .On the same day, all patients underwent imaging planar whole-body scan(WBS) and SPECT/CT 5-7 days after taking the prescribed oral iodine dose.

Inclusion criteria

All patients with histologically confirmed high-risk and intermediate-risk thyroid carcinoma and after a full or nearly full thyroid surgery, individuals who received radioactive iodine therapy were included in this research.

Exclusion criteria

breastfeeding mothers and pregnancy.

2.1 Scintigraphy protocol

All body planar scan and SPECT/CT examinations of the device type (a General Electric GE, Model: Discovery 670 NM/CT) for all patients were performed on the same day, 5 – 7 days after iodine-131 administration. It consists of two heads of gamma cameras, 1.5875 cm NaI crystals (sodium iodide), and a tube computed tomography with 16 rows of detectors of the type of nuclear medicine 670 (NM670 GE). Parallel-hole collimator with high energy was employed (364 keV). Coronal, sagittal, and transverse slices were produced. Spiral tomography gamma camera in the same arch took SPECT and CT images. In the same position, and SPECT/CT was performed during the same whole-body planar imaging session on the neck and chest with the patient, including the patient's arms in the same position for a 30-minute scan duration. All patients received SPECT/CT imaging from the skull to the knee, including abdominal and pelvic imaging. A Xeleris workstation (NM670; General Electric GE Discovery Medical Systems, Milwaukee, GE Healthcare) reconstructed and merged the SPECT and CT images. The planar imaging and SPECT/CT data had been reconstructed. The process did not use a contrast medium.

2.2 Image analysis

All images from conventional imaging and SPECT/CT had been analyzed independently by two qualified nuclear medicine doctors. First, uptake foci had been discovered, which were later categorized as thyroid remains after being determined to be localized in the thyroid fundus. Focuses that were laterally positioned inside the neck and clearly distinct at the posterior section had been classified as good for thyroid bed absorption, and those that were close to the anterior part were evaluated as unclear. The results of iodine-131 SPECT/CT were contrasted with those of planar imaging acquired with a Xeleris workstation-specific. In all the patients, concentrated iodine-131 absorption had been compared from SPECT/CT results and declared positive if these were in agreement with small lung nodules or degenerating bony lesions. When it was difficult to determine the anatomical location or foci of resorption, planar data were viewed as equivocal or indistinct. As SPECT/CT fusion images provided improved identification and interpretation of foci of resorption, accurate location, and anatomical as well as variations between neoplastic and physiological lesions, an additional value of iodine-131 planar imaging of the whole body.

3. Results

The characteristics of patients with thyroid cancer are presented in Table 1. Characteristics include age, thyroid-stimulating hormone (TSH) mU/L, tumor size (cm), sex, histological type, body region of origin, and therapeutic dose of iodine-131 (mCi). The majority of patients were women. The more typical histological type in patients with thyroid cancer was papillary thyroid cancer (PTC) (91.67%), followed by follicular thyroid cancer (FTC) (5%) and the Herthel cell (3.33%). The metastatic cancer origin of thyroid cancer arises mainly from the neck (47.19%), chest and abdomen (23.60%), pelvis (12.36%), equivocal (10.11%), and bone metastases (6.74%).The highest percentage of radioiodine doses given to patients with thyroid cancer was 100 mCi (38.13%), followed by a 120 mCi (43.33%) therapeutic dose, 150 mCi for intermediate risk, and for high risk, a therapeutic dose of 175 mCi (6.67%), 180 mCi Curie (1.67%), and 200 mCurie (6.67%), as shown in the Table 1.

3.1 Thyroid carcinoma with or without lymph nodes metastasis (mLN)

Thyroid cancer patients were classified according to whether the tumor had metastasized to distant sites or not, and the parameters are shown in Table 2. The age of patients without lymph nodes metastasis (mLN) was greater than that of patients with LN metastasis, without significant difference. Most patients had lymph node (LN) involvement. TSH levels (mU/L) in thyroid carcinoma pations with metastasis lymph nodes were significantly higher than in those without the lymph nodes. With the exception of the thyroid-stimulating hormone (TSH), there were no discernible variations in the clinicopathological variables, and the tumor volume (cm) was greater in patients with lymph nodes (LN) than in those without lymph nodes (LN). The tumor classification for patients without lymph nodes was T2, followed by T1, and only one patient was classified as T3. By comparison, most patients with lymph nodes are classified as T2, T1, and T3, respectively. There was a very significant difference between patients with and without lymph nodes for T classification. The following are the final The American Thyroid Association (ATA) risk stratifications that were determined after examining the data from the iodine-131 scan were: distant metastasis (Mx or M_0) (14/0 points) is considered intermediate-risk, and distant metastasis (M1) (5/41 points) is considered high-risk. As a solution was evaluated, unexpected distant and local metastases were found, which led to the ATA risk classification being changed to the high-risk category. Intermediate-risk patients have tumor classifications of T1 and T2 only. People at high risk have mainly T2, followed by T1, then T3, where T3 is a tumor larger than 4 cm in size and extending into the soft tissues surrounding the both within and without the thyroid gland. Desire for radioactive iodine makes the higher in patients with lymph node metastasis compared to people without mLN.

3.2 The original region of metastasized cancer

Table 3 shows the comparison results for patients who were imaged on planar imaging and SPECT/CT for each patient, and this difference appeared based on the evidence of the presence of a multifocal area of increased iodine deficiency in the fundus of the thyroid gland, which is the area of origin of metastatic cancer in SPECT/CT compared to planar imaging. Planar scans depicted 86 foci of iodine-131 activity, classified as 45 neck foci and 41 distal foci. The majority of radioactive iodine uptake foci are located in the lung and

Table 1. Characteristics of patients with thyroid carcinoma.

Characteristics of patients		Statistic
Age (Years)	Mean ± SD	45.85 ± 12.62
Thyroid-stimulating hormone (TSH mU/L)	Mean ± SD	68.99 ± 23.93
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%

Table 2. Comparison between thyroid cancer with or without lymph nods.

Parameters	Without LN	With LN	p-value
Age	47.64 ± 3.378	45.30 ± 1.874	0.549
Number of patients	14	46	$< 0.001*$
TSH mU/L	62.33 ± 6.340	71.02 ± 3.522	0.0237*
Tumor size (cm)	3.075 ± 0.513	2.940 ± 0.283	0.0891
Tumor classification (T1/T2/T3)	6/7/1	14/24/8	$< 0.001*$
Distant metastasis Mx or M_0/M1	14/0	5/41	$< 0.001*$
Administered RAI activity (mCi) (100/120/150/175/180/200)	10/2/2/0/0/0	13/24/0/4/1/4	$< 0.001*$
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.

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. 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. Mainly, SPECT/CT has been shown to have better resolution than gamma graphs and show more details of the tumor, as shown in the Figure 1.

4. Discussion

In this study, every patients received an oral therapeutic dosage of iodine-131 after at least a 3-week period of thyroxin abstinence, which improved the outcomes of iodine-131-planar WBS and SPECT/CT. It can be done following after 5 days of the administration of a therapeutic dose of RAI (100 – 200 mCi). Planar scan and SPECT/CT data were interpreted very differently for LN metastases and distant metastases, identifying sites of iodine uptake in some patients as it was judged equivocal, especially in the neck area, where the frequency of equivocal foci and cervical action in the middle was classified as a locoregional or thyroid residual illness because whole-body scan is an image acquired in the front and back projections, and it was hard to clearly determine location with absorption. SPECT/CT interpreted the foci of iodine uptake sites thought to be equivocal detected on planar imaging, and it determined the spatial localization of hot spots. They were majority of radioactive iodine uptake foci are located in the lung and bone. Computed tomography (CT), as well as SPECT, provided foci and anatomical locations of iodine uptake in hot areas that are difficult to identify on planar imaging. There was physiologic accumulation on planar imaging, and this accumulation was in areas of the floor of the mouth, salivary glands, colon, stomach, and bladder that were judged to be

Table 3. Comparison between the findings of ^{131}I Planar whole-Body scan and SPECT/CT findings.

Patient No.	Region of body	Planar ^{131}I-WBS findings	Characterizing ^{131}I SPECT/CT findings
1	Neck	Equivocal	Lymph node metastasis
2	Neck	Equivocal	Lymph node metastasis
3	Neck	Thyroid remnant	Thyroid remnant
4	Neck	Thyroid remnant	Thyroid remnant
5	Neck	Equivocal	Lymph node metastasis
6	Neck	Equivocal	Lymph node metastasis
7	Neck	Equivocal	Thyroid remnant
8	Neck	Equivocal	Thyroid remnant
9	Chest, Abdomen/pelvis	Equivocal in lung	Lung and bone metastasis and Physiologic activity in the colon
10	Chest, Abdomen/pelvis	Equivocal in lung	Lung and bone metastasis and Physiologic activity in the bladder

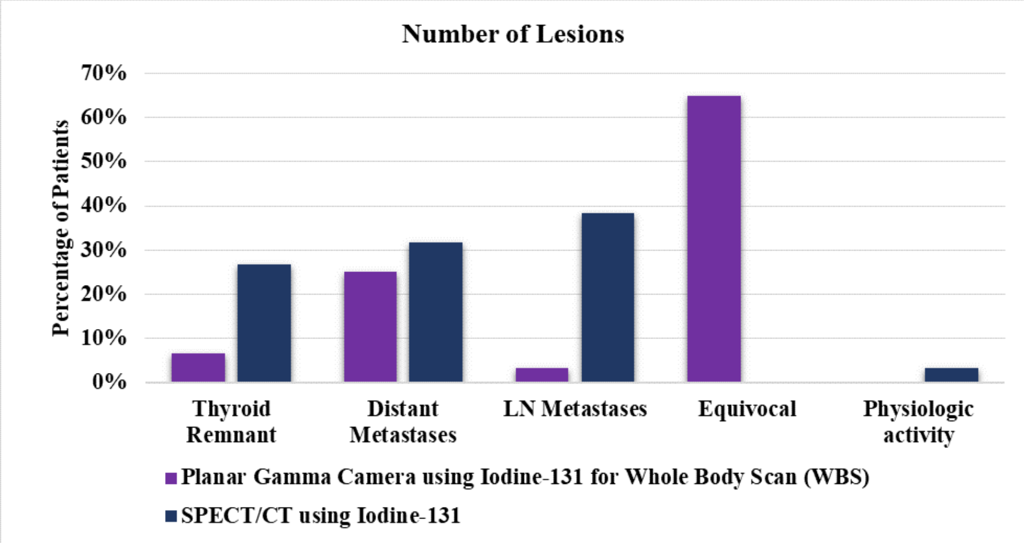

Figure 1. Comparison of types of lesions detected by planner gamma camera versus SPECT/CT.

equivocal findings of distant metastasis. Additional details on RAI-avid metastatic foci are provided by the SPECT/CT and planar scan combinations. Compared to another study by Wang et al. in 2009, they showed that 7% of individuals can have new metastatic lesions that planar scans miss identifying by SPECT/CT [5]. Additionally, Jeong et al. observed that 5.2% of patients had unfavorable outcomes from planar scans, which was discovered using SPECT/CT [6]. The results of the current study showed that the interpretation of uptake foci on whole-body planar imaging changed when the SPECT/CT results were reviewed, and the treatment plan had changed in 26 (43%) of 60 patients. This change was due to dependence on iodine uptake sites in the foci. Therefore, for a total of 62 of the 86 iodine-131 foci (72%), in comparison with conventional scans, SPECT/CT had a greater additional impact, identifying 45 of the 86 cervical lesions in the middle (52.3%) and 15 of the 19 distant foci (78.9%) of the thyroid cancer patients. In this investigation, the increased diagnostic utility of SPECT/CT proved higher compared to another study that provided an SPECT/CT that produced a total gain in information for 44% of the patients compared to planar imaging, resulting in a new approach to patient treatment, according to 2015 research by Shinto et al. [7]. Also, in follow-up research conducted in 2020 by Spanu et al., the diagnostic value for SPECT/CT over a whole body scan was 57% in patients with thyroid cancer [8]. There was another study whose results were similar to the findings of the present research, with a lower value of 70.7%. This was research by Iizuka et al. in 2021 that found that using SPECT/CT had a greater diagnostic value than a whole-body scan [9].

5. Conclusion

In conclusion, patients who received an oral therapeutic dosage of iodine-131 SPECT/CT imaging delivered considerably more diagnostic data and an added advantage over whole-body planar scan in this research compared to a planar whole-body scan alone. Iodine-131 SPECT/CT is more valuable in the management of treatment than iodine-131 planar whole-body scan (WBS), and it can also be used to calculate the dosage of radioiodine therapy and guide surgery.

Ethical approval
This manuscript does not report on or involve the use of any animal or human data or tissue. So the ethical approval is not applicable.

Authors Contributions
All the authors have participated sufficiently in the intellectual content, conception and design of this work or the analysis and interpretation of the data (when applicable), as well as the writing of the manuscript.

Availability of data and materials
The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Conflict of Interests
The author declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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