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Clinical Utility of SPECT/CT Imaging Post-Radioiodine Therapy: Does It Enhance Patient Management in Thyroid Cancer?

Fahim U. Hassan Hosahalli K. Mohan

Nuclear Medicine Department, Borough Wing, Guy's Hospital, London, UK

Key Words
Radioiodine · Single-photon emission computed tomography/computed tomography · Thyroid cancer

Abstract
Background: The aim of this study was to evaluate post-therapy iodine-131 single-photon emission computed tomography/computed tomography (^{131}I-SPECT/CT) imaging in comparison to conventional planar ^{131}I whole-body imaging, and to assess its clinical impact on the management of patients. ***Methods:*** We retrospectively reviewed planar ^{131}I whole-body and ^{131}I-SPECT/CT imaging findings in 67 patients who underwent ^{131}I therapy for thyroid cancer. Two nuclear medicine physicians reviewed the scans independently. The foci of increased tracer uptake were identified in the neck, thorax and elsewhere. Within the neck, the foci of ^{131}I-increased uptake were graded qualitatively as probable or definite uptake in thyroid remnants and probable or definite uptake in the lymph nodes. Serum thyroglobulin level, histopathology and other imaging findings served as the reference standard. ***Results:*** Of the 67 patients, 57 (85%) had radioiodine avid disease and 10 (15%) demonstrated non-radioiodine avid disease. Overall, post-therapy ^{131}I-SPECT/CT downstaged lymph node staging in 10 patients and upstaged it in 4 patients. This translated into a change of management for 9/57 (16%) patients with radioiodine avid disease. A change of management was observed in 5/10 patients with non-radioiodine avid disease confirmed in the post-^{131}I-SPECT/CT study. Additionally, clinically significant findings such as incidental lung cancer, symptomatic pleural effusion and consolidation were also diagnosed in both groups of patients. ***Conclusion:*** In patients with thyroid cancer, ^{131}I-SPECT/CT is a valuable addition to standard post-therapy planar imaging. SPECT/CT also improved diagnostic confidence and provided crucial clinical information leading to change of management for a significant number of these patients.

Introduction

Thyroid cancer, although rare, is the most common endocrine malignancy, making up 1% of all malignancies [1]. Well-differentiated thyroid cancer accounts for >90% of thyroid cancers, mainly the papillary and follicular types. The incidence of thyroid cancer is on the increase in Europe and the rest of the world in the last 3 decades [2, 3].

More than 80% of patients with well-differentiated thyroid cancer have an excellent prognosis with a 20-year cause-specific mortality rate of <1% [4]. In the remaining 20% of patients, the disease course is variable and includes recurrences, metastatic disease and, in some cases, death.

The main factors which affect the prognosis at the time of diagnosis include: male gender, age, tumour size, his-

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Fahim-Ul-Hassan
Nuclear Medicine Department, Borough Wing
Guy's Hospital, Great Maze Pond
London SE1 9RT (UK)
E-Mail drfahim.hassan@gmail.com

tological subtypes, extrathyroidal spread, metastatic disease and iodine avidity [5].

Surgery, which includes total thyroidectomy and lymph node dissection followed by radioiodine ablation, remains the mainstay of treatment for a large majority of patients. Follow-up is life-long with thyroid-stimulating hormone (TSH) suppression and thyroglobulin monitoring.

Imaging plays a vital role in the detection, diagnosis, accurate staging and optimal management of patients with differentiated thyroid cancer. Functional imaging using iodine-123 and iodine-131 (^{131}I), in particular, provides information regarding suitability for therapy and the comprehensive staging of disease.

Ultrasound remains the first line of investigation for the assessment of thyroid nodules. This, combined with fine-needle aspiration, is helpful in pre-surgical assessment of thyroid nodules and neck lymph nodes and post-surgery in the assessment for recurrent thyroid cancer in these patients. The diagnostic accuracy with fine-needle aspiration under ultrasound guidance has been reported to be in the range of 85–94% [6].

Standard current practice in patients with well-differentiated thyroid cancer following surgery for accurate staging of the disease is to perform whole-body imaging following ^{131}I ablative therapy [7].

However, planar ^{131}I whole-body imaging has limited resolution, which can result in inaccurate localisation and characterisation of the abnormal and sometime physiological radioiodine uptake [8]. In addition, in a small number of patients with non-radioiodine avid disease, whole-body ^{131}I imaging is of no proven value.

Single-photon emission computed tomography (SPECT) imaging has better resolution than planar ^{131}I whole-body imaging. SPECT imaging, which involves acquiring data in 3 dimensions, displays improved lesion localisation, but it may not be accurate enough to characterise this due to a lack of anatomical markers [8].

Hybrid imaging (SPECT/CT) involves a combination of functional and structural data in a single imaging session. This is a relatively new technique which has been shown to improve localisation and characterisation of iodine avid and non-avid abnormalities, and can lead to changes in the management of the disease [9, 10].

The aims of this study were: (1) to identify the additional role of post-therapy ^{131}I-SPECT/CT compared to conventional planar ^{131}I whole-body imaging in thyroidectomised thyroid cancer patients and (2) to assess the impact of ^{131}I-SPECT/CT on further patient management.

Materials and Methods

This was a retrospective review of 67 patients (2007–2008) diagnosed with thyroid cancer. They were referred either for initial post-surgical ^{131}I ablation or for subsequent ^{131}I therapy of residual, recurrent or metastatic disease. All patients underwent planar whole-body imaging and SPECT/CT imaging.

There were 44 female and 23 male patients with an age range of 22–82 years; 58 patients had a diagnosis of papillary thyroid cancer and 9 of follicular thyroid cancer; 29 patients had 1 radioiodine therapy and 38 had subsequent radioiodine therapies for remnant, recurrence or metastatic disease.

The prescribed activity of ^{131}I which patients received varied from 3.7 to 7.4 GBq. All 29 patients who had 1 therapy were given 3.7 GBq of ^{131}I. In all patients, thyroid functions were checked to ensure that the level of TSH was >30 miU/l prior to radioiodine therapy. In 24 patients, this was achieved following recombinant TSH (Thyrogen, Genzyme) injections and in 43 (64%), it was achieved following tri-iodothyronine (T_3) withdrawal for 2 weeks or thyroxine (T_4) withdrawal for 4 weeks prior to therapy. All patients were on a low-iodine diet for 3 weeks prior to radioiodine treatment.

The data collected included initial post-surgical staging of the disease, histological type/grade and clinical follow-up obtained from medical notes, multi-disciplinary team-meeting correspondence and electronic patient records.

Imaging Protocol

Planar ^{131}I whole-body imaging was performed 2–5 days after radioiodine therapy. Additional planar images of the neck and chest were obtained in the anterior and posterior projections using a dual-head gamma camera (Philips Precedence™) according to the departmental imaging protocol.

Planar Imaging

A marker view was first obtained using ^{57}Co positioned on the chin and suprasternal notch (energy window 122 keV ± 10%) for 1 min. Neck views and a whole-body scan (WBS) were acquired by using a high-energy, high-resolution collimator (neck: matrix 256 × 256, energy window 364 ± 10% and WBS: matrix 256 × 1,024, energy window 364 ± 20%). Scan speed was 30–80 mm/min depending upon the count rate from head to knees.

A Philips Precedence™ gamma camera equipped with an integrated X-ray transmission system (16-slice CT) provided anatomical imaging for attenuation correction and image fusion.

SPECT/CT was performed during the same session as the whole-body planar imaging. SPECT /CT images of the neck and thorax were performed in all patients, and additional SPECT/CT images were acquired in 5 patients (e.g. of the abdomen and pelvis). CT images were acquired using a fixed protocol (120 keV, 100 mAs/slice). The slice thickness was 1.5 mm and the increment was 0.75 mm.

SPECT images were then acquired with a high-energy, high-resolution collimator (matrix 64 × 64) and 64 projections over 360° of the dual-head gamma camera. The energy window of 10% was centered over 364 keV. Processing was achieved with ordered-subsets expectation maximisation (5 iterations for 8 subsets) and resolution recovery.

Data Analysis

All images were analysed independently by 2 experienced nuclear medicine physicians who were blinded to clinical details. Pla-

Table 1. Planar and SPECT/CT imaging findings

	Probable	Definite
Neck		
Planar imaging		
Thyroid remnants	5	23
Lymph nodes	12	5
SPECT/CT		
Thyroid remnants	0	34
Lymph nodes	1	10
Thorax and skeleton		
Planar imaging		
Esophagus		4
Mediastinal nodes		7
Lungs		10
Bones		4
SPECT/CT		
Esophagus		6
Mediastinal nodes		4
Lungs		11
Bones		4

nar imaging was reviewed on HERMES workstation. Scintigraphic results were considered to be physiological/normal if the areas of increased activity were in salivary glands and the linear uptake in the oesophagus, nasopharyngeal area, gastrointestinal tract and urinary bladder.

For the neck, ^{131}I uptake on the planar and SPECT/CT images was qualitatively assessed and classified as:

- definite thyroid remnant;
- probable thyroid remnant;
- definite lymph node uptake;
- probable lymph node uptake.

On the planar imaging, the focus of uptake was called a thyroid remnant if the uptake was in the thyroid bed. If the uptake was outside the thyroid bed, it was classified as possible/definitive lymph node uptake.

In the thorax, abnormal uptake of iodine was categorised into:

- definite mediastinal node uptake;
- probable mediastinal node uptake;
- definite uptake in lungs.

Elsewhere, the iodine uptake was categorised as:

- definitely in the skeleton or within the soft tissue.

The ^{131}I-SPECT/CT findings were reviewed on a dedicated Excellence Brilliance work station. The ^{131}I-SPECT/CT was considered contributory if it resulted in a change in staging or had an impact on management. It was considered beneficial if additional significant clinical findings were seen on the CT component.

In patients where ^{131}I-SPECT/CT findings led to a change of management, the findings were confirmed on pathological samples (if surgery was undertaken) and clinical follow-up, including serum thyroglobulin monitoring for up to 2 years post-therapy. Any other correlative imaging information including neck ultrasound was also collected.

Results

A large majority of patients, i.e. 57/67 (85%) had evidence of radioiodine avid disease and 10 demonstrated non-^{131}I avid disease. Of the 57 with iodine avid disease, 47 were diagnosed as having papillary thyroid cancer and 10 as having follicular thyroid cancer. Iodine uptake showed up on either on planar or SPECT/CT imaging in the neck in 45 patients and thorax/skeleton in 25.

Impact of SPECT/CT on Disease Staging in the Neck

Table 1 shows the results of planar and SPECT/CT imaging findings in the neck. In the 45 patients with iodine avid residual disease in the neck, a dramatic improvement was seen in the number of definitive reports issued, with a reduction in equivocal reports (probable uptake), i.e. from 17 noted on the planar study review to only 1 that was issued following the review of the SPECT/CT data. This was considered to be a result of the improved diagnostic confidence of the clinician due to the superior localisation and characterisation of iodine uptake on SPECT/CT.

In one case, there was a large thyroid remnant and it was not possible to delineate adjacent uptake which was thought to be in a lymph node on SPECT/CT.

Downstaging

In the neck, there was downstaging of 8 patients where planar imaging was reported as definite in the lymph nodes and uptake in the thyroid remnant (fig. 1).

Upstaging

SPECT/CT upstaged disease in 3 patients. In 2 patients, the uptake was attributed to probable thyroid remnants on planar imaging. This was found to actually be in the lymph nodes on SPECT/CT (fig. 2) in 1 of these patients and in the other, SPECT/CT localised the uptake to unusual pathological uptake in the left sternocleidomastoid muscle.

Hybrid imaging provided additional information on the size and level of the lymph nodes. On SPECT/CT, 1 patient had a large haematoma at the site of surgery which needed draining.

Impact of SPECT/CT on Disease Staging within the Thorax and Skeleton

See table 1 for a summary of the results of the planar and SPECT/CT imaging of the thorax and skeleton.

Downstaging

There was downstaging of disease in 2 patients. In 1 patient, planar imaging was reported as definite in the

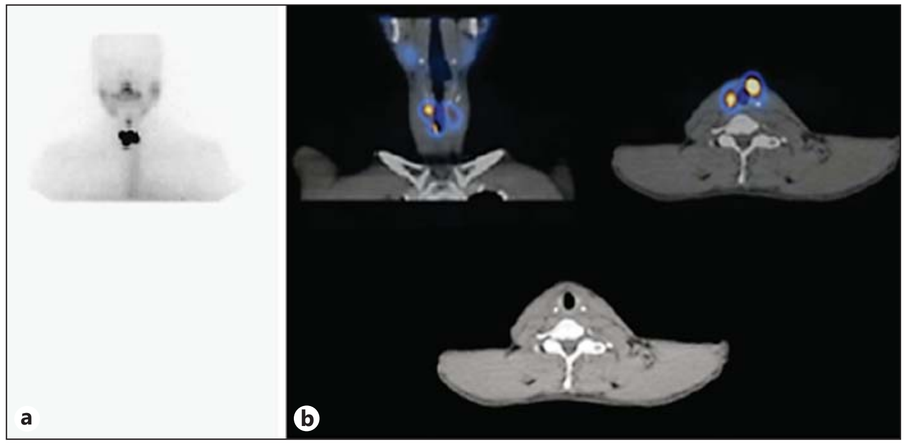

Fig. 1. Lymph node downgrading: on the planar images (**a**), the multifocal uptake is graded to be a nodal disease. **b** SPECT/CT showed the corresponding uptake within the thyroid remnant.

lymph node. This was downgraded to physiological oesophageal uptake. In the other patient, uptake was reported in the lungs and asymmetrical physiological uptake in the breast tissue.

Upstaging

In 1 patient, the uptake attributed to the oesophagus on planar imaging was found to actually be in a mediastinal lymph node on SPECT/CT.

SPECT/CT in Evaluation of Bone Metastases

Four patients in total (7%) had bony metastatic disease on planar and SPECT/CT imaging. Again, SPECT/CT was superior for the precise localisation and assessment of the extent of bone involvement.

Significant Incidental Findings on SPECT/CT

The CT component of the study showed additional findings in 10 patients (17%). Three had consolidation, 2 had pleural effusion, and in 1 patient each, pericardial effusion, rib fracture, right inferior pubic ramus fracture, lung cancer and spinal cord compression were diagnosed.

Change of Management Due to Significant SPECT/CT Finding

Information obtained from SPECT/CT imaging in addition to planar imaging changed the management of 8 patients (14%). Three underwent further surgery in the neck for metastatic lymph node disease. One had a metastatic nodule removed from the left sternocleidomastoid muscle. Histology confirmed metastatic disease, and the subsequent serum thyroglobulin level was markedly reduced. One patient underwent further radioiodine therapy for mediastinal nodal disease.

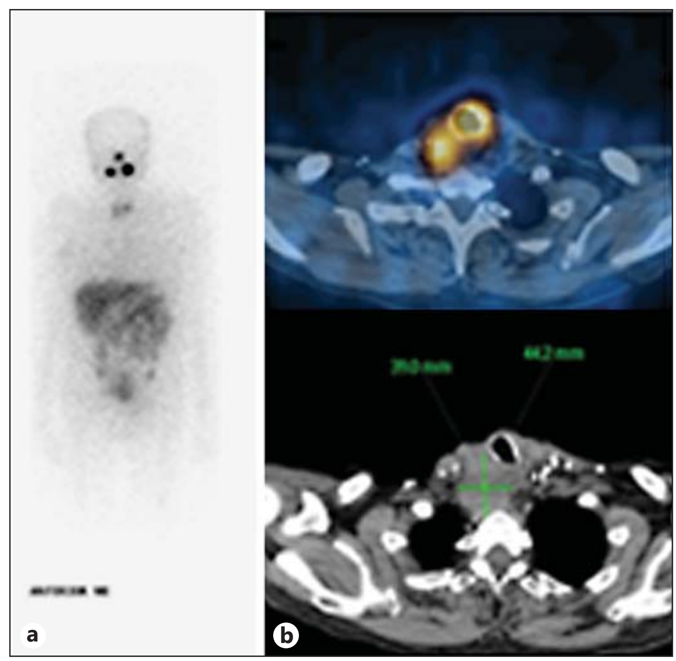

Fig. 2. An example of lymph node upstaging in a patient with a history of papillary thyroid cancer where uptake was graded as a possible thyroid remnant on the planar study (**a**). **b** SPECT/CT showed a large nodal mass in the right lower neck. The patient was referred for surgery.

Two patients were referred for radiotherapy of symptomatic skeletal metastases, including impending spinal cord compression (fig. 3).

One patient was referred to chest physicians for the management of suspected lung cancer and another for the management of symptomatic pleural effusion.

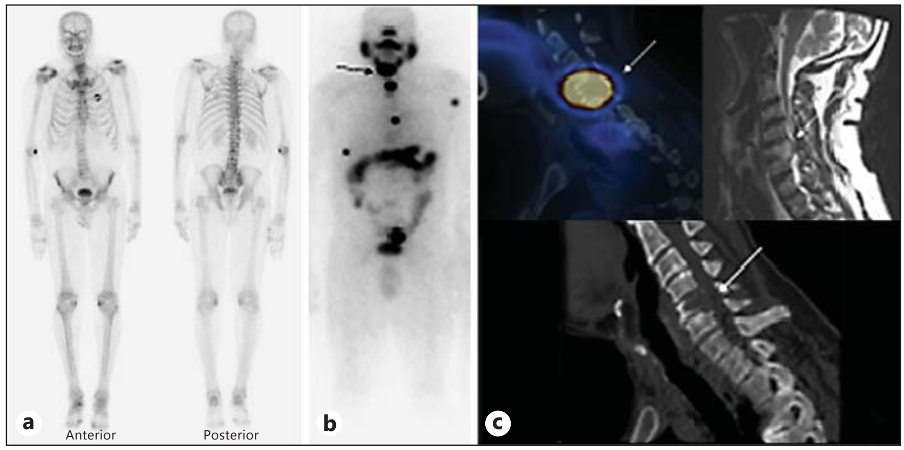

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Fig. 3. The patient presented with a left-sided chest wall mass, and the bone scan (**a**) showed abnormal uptake in the left 3rd rib, the biopsy of which revealed metastatic follicular thyroid cancer. **b** Post-radioiodine therapy whole-body images showed multiple skeletal metastases. **c** ^{131}I-SPECT/CT showed lytic metastases in the cervical spine (arrows) also confirmed on MRI. The patient was referred for urgent spinal stabilisation.

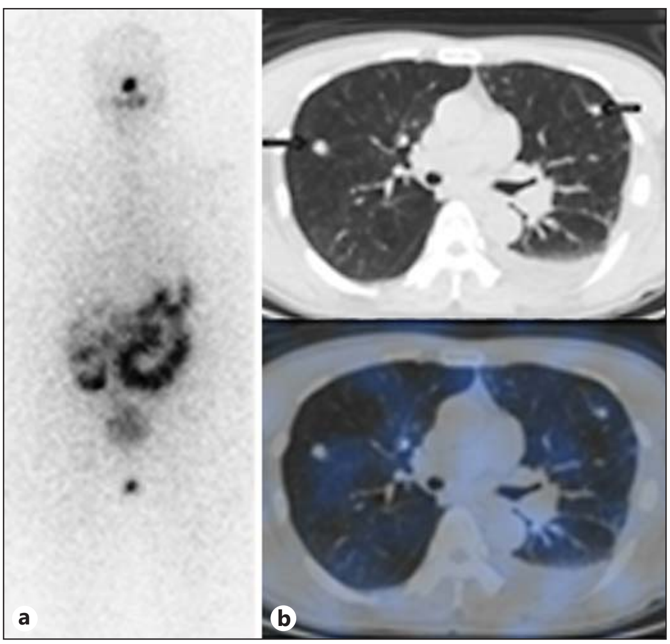

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Fig. 4. a A patient with a rising thyroglobulin level and negative planar whole-body imaging. **b** SPECT/CT showed multiple non-radioiodine avid lung metastases (arrows) and left pleural effusion.

^{131}I-SPECT/CT in Non-Radioiodine Avid Disease

In total, 10 patients (15%) had non-radioiodine avid disease. SPECT/CT imaging was extremely helpful in these cases, where the thyroglobulin level was raised but the post-therapy planar imaging was negative. Nine patients had an initial diagnosis of papillary thyroid cancer and 1 had a diagnosis of follicular thyroid cancer.

^{131}I-SPECT/CT was helpful in all 10 patients with non-avid disease when planar WBS was negative. The CT component of SPECT/CT revealed disease including local recurrence in the neck and thorax, skeletal metastases and additional significant findings.

In the neck, 2 patients had pathological cervical lymphadenopathy which was non-radioiodine avid. They were referred for surgical clearance of lymph nodes; this confirmed de-differentiated disease.

In the thorax, 5 patients had mediastinal disease and 8 had lung metastases (fig. 4). They underwent follow-up CT and PET/CT studies to assess suitability for novel tyrosine kinase inhibitor therapy. One patient who demonstrated symptomatic lytic bony metastasis of the sternum was referred to radiotherapy. Another significant clinical finding was in 1 patient who had incidental primary lung cancer and was referred to the respiratory physician. This was subsequently diagnosed as adenocarcinoma of the lung.

Follow-Up

Medical follow-up of 2–5 years was obtained for all patients. All of those with iodine avid disease who had disease downgrading did not need a second therapy at the 6-month follow-up (confirmed by a negative stimulated thyroglobulin). They remain well on a suppressive dose of thyroxine with a negative thyroglobulin.

Patients who underwent surgery with or without radioiodine therapy for residual disease in the lymph nodes/soft tissue are well with no further episodes of recurrent disease and a negative thyroglobulin at follow-up.

Two patients who required adjunctive radiotherapy and additional radioiodine therapy for symptomatic skeletal disease continue to remain well and demonstrate stable disease and a significant drop in thyroglobulin on imaging.

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Of the 10 patients with non-iodine avid disease, 5 were treated with tyrosine kinase inhibitors. Of these, 4 responded to treatment and are alive, but the fifth died after progression of the disease. Of the 5 patients who were not on any treatment, 4 have died and 1 has stable disease.

Discussion

^{131}I remains the cornerstone of post-surgical treatment in patients with differentiated thyroid cancer. A post-planar ^{131}I-WBS remains standard imaging practice after radioiodine therapy for differentiated thyroid cancer. This allows for accurate staging of the disease and tailors the management for the patient appropriately. However, it is well known that the results of planar imaging are either false-positive or equivocal in some patients [11]. Post-therapy ^{131}I-SPECT/CT in recent years has been shown to overcome the deficiencies of planar imaging and to aid in the overall management of these patients.

In our study, SPECT/CT provided valuable additional information for 62% of the patients when compared to planar imaging. This was possible due to the superior and accurate localisation and characterisation of sites of ^{131}I uptake. This meant a dramatic reduction in the number of equivocal reports which would have resulted in unnecessary investigations. This finding is similar to others reported in the literature. Spanu et al. [12] found that, in 35.6% of patients with positive findings, a more appropriate decision about therapeutic management was made following SPECT/CT review. Schmidt et al. [10] reported that SPECT/CT compared to planar imaging provided incremental information on nodal staging after the first radioiodine treatment in 35% of patients, and that it altered the risk stratification in 25% of patients. Post-radioiodine SPECT/CT was seen to improve accuracy in 24.5% of patients compared to planar imaging in nodal staging in T1 papillary thyroid cancer [13].

Grewal et al. [14] demonstrated that post-therapy SPECT/CT reduced the need for additional cross-sectional imaging in 20% of patients, and significantly altered the risk of initial recurrences in 6.4% of patients, resulting in a change of management.

In our study, the change in disease stage in 14/57 patients translated into tailoring of therapy which included further surgery, radioiodine therapy and radiotherapy at sites that were at risk of pathological fracture in these patients. SPECT/CT was particularly useful for the assessment of non-radioiodine avid disease in patients where planar scintigraphy was negative. Incidental significant pathologies were also identified including primary lung cancer and pleural effusion; these required further management.

Pre-therapy iodine-123 SPECT/CT and ^{131}I-SPECT/CT studies have demonstrated improved specificity, a reduction in the number of equivocal diagnoses and improved interpretation of planar imaging [15, 16].

Schmidt et al. [17] showed that ^{131}I-SPECT/CT has a high negative predictive value with regard to the occurrence of radioiodine-positive cervical nodes 5 months after the initial therapy.

Our study confirms the incremental benefit of SPECT/CT over planar imaging. This has a significant impact on management. We had the benefit of a prolonged period of follow-up (2–5 years) in these patients. To our knowledge, it is the only study with such a long follow up for patients managed with SPECT/CT imaging.

In patients where the disease was downgraded, the major benefit was that further investigations, futile therapies and unnecessary radiation exposure could be avoided. In patients where there was disease-upgrading, there was appropriate further management including surgery or other therapies. Detection of disease and treating the patients earlier were made possible, with subsequent excellent outcomes. This was backed by the reasonably long, recurrence-free follow-up period. This confirms the supposition raised by Mustafa et al. [13], Grewal et al. [14] and Schmidt et al. [17] in their studies regarding the benefits of SPECT/CT for reducing the risk of recurrence in the future. Important here is the potential to reduce patient morbidity and mortality by ensuring appropriate treatment is delivered early/at the right time.

As a one-stop imaging technique, SPECT/CT would reduce the inconvenience to the patients by limiting the number of visits to the hospital as well as the radiation exposure from additional diagnostic CT studies. This is also cost-beneficial to the patient and the system.

Due to the experience gained from this study, routine post-therapy ^{131}I-SPECT/CT imaging is currently performed in the following group of patients in our institution:

- patients with high-risk cancer [7];
- iodine uptake in the neck which is disproportionate to initial disease and staging;
- any abnormal iodine uptake outside the neck, for accurate localisation and characterisation;
- in patients with a raised thyroglobulin level and negative iodine whole-body scintigraphy.

Limitations of Our Study and of ^{131}I-SPECT/CT

Our study was a retrospective analysis of the initial data when SPECT/CT became available in our institution. It was part of a service evaluation and there was an element of learning experience. There are certain limitations to the use of SPECT/CT that relate to both the functional and structural imaging components. The 'low-dose' CT component generates a lower intensity X-ray beam, compared to diagnostic CT, resulting in noisier images of lower spatial resolution. This may impact on the detection of micro-metastases from local invasion of differentiated thyroid cancer or in the cervical lymph nodes. It may also be disadvantageous to surgical candidates who need a high-resolution diagnostic CT to evaluate the extent of disease and its relation to the surrounding anatomical structures [18].

Misregistration, though significantly reduced with integrated SPECT/CT systems, is still a possibility. This was seen in 8 patients in our study; however, it was to a minimal degree and did not have any impact on final outcome. One study reported this as a cause for misinterpretation in 1 patient [19].

One patient in our study had a large thyroid remnant which made it difficult to rule out uptake in adjacent lymph nodes on the SPECT/CT as well. This was also observed by Wong et al. [16] in their study which highlighted the difficulty of SPECT/CT in differentiating thyroid remnant tissue/residual disease from nodal metastases in the central compartment of the neck, and it led to incorrect downstaging in 7 patients.

Lastly, this was a small cohort and it was difficult to conclude significant statistical benefits, so we decided to use descriptive statistics only. A much larger sample is needed for attaining significant statistics.

Conclusion

SPECT/CT demonstrates a distinct benefit over the current standard post-therapy planar ^{131}I imaging in patients with radioiodine avid disease or de-differentiated disease. This has proven to be a valuable technique which needs to be incorporated into the imaging pathways of patients with thyroid cancer.

Disclosure Statement

There were no disclosures.

References

1 Davies L, Welch HG: Increasing incidence of thyroid cancer in the United States, 1973–2002. JAMA 2006;295:2164–2167.

2 Silva DS, Swerdlow AJ: Thyroid cancer epidemiology in England and Wales: time trends and geographical distribution. Br J Cancer 1993;67:330–340.

3 Pettersson B, et al: Trends in thyroid cancer incidence in Sweden, 1958–1981, by histopathologic type. Int J Cancer 1991;48:28–33.

4 Randolph GW, et al: Treatment of thyroid cancer: 2007 – a basic review. Int J Radiat Oncol Biol Phys 2007;69:S92–S97.

5 Abraham T, Schoder H: Thyroid cancer – indications and opportunities for positron emission tomography/computed tomography imaging. Semin Nucl Med 2011;41:121–138.

6 Vojvodich SM, et al: Accuracy of fine needle aspiration in the pre-operative diagnosis of thyroid neoplasia. J Otolaryngol 1994;23:360–365.

7 Royal College of Physicians in association with the British Thyroid Association: Guidelines for the Management of Thyroid Cancer, ed 2. London, Royal College of Physicians, 2007, p 83.

8 Yamamoto Y, et al: Clinical usefulness of fusion of ^{131}I SPECT and CT images in patients with differentiated thyroid carcinoma. J Nucl Med 2003;44:1905–1910.

9 Townsend DW, Cherry SR: Combining anatomy and function: the path to true image fusion. Eur Radiol 2001;11:1968–1974.

10 Schmidt D, et al: Impact of ^{131}I SPECT/spiral CT on nodal staging of differentiated thyroid carcinoma at the first radioablation. J Nucl Med 2009;50:18–23.

11 McDougall IR: Whole-body scintigraphy with radioiodine-131. A comprehensive list of false-positives with some examples. Clin Nucl Med 1995;20:869–875.

12 Spanu A, et al: ^{131}I SPECT/CT in the follow-up of differentiated thyroid carcinoma: incremental value versus planar imaging. J Nucl Med 2009;50:184–190.

13 Mustafa M, et al: Regional lymph node involvement in T1 papillary thyroid carcinoma: a bicentric prospective SPECT/CT study. Eur J Nucl Med Mol Imaging 2010;37:1462–1466.

14 Grewal RK, et al: The effect of posttherapy ^{131}I SPECT/CT on risk classification and management of patients with differentiated thyroid cancer. J Nucl Med 2010;51:1361–1367.

15 Barwick T, et al: Single photon emission computed tomography (SPECT)/computed tomography using iodine-123 in patients with differentiated thyroid cancer: additional value over whole-body planar imaging and SPECT. Eur J Endocrinol 2010;162:1131–1139.

16 Wong KK, et al: Staging of differentiated thyroid carcinoma using diagnostic ^{131}I-SPECT/CT. AJR Am J Roentgenol 2010;195:730–736.

17 Schmidt D, et al: Five months' follow-up of patients with and without iodine-positive lymph node metastases of thyroid carcinoma as disclosed by ^{131}I-SPECT/CT at the first radioablation. Eur J Nucl Med Mol Imaging 2010;37:699–705.

18 Chen L, et al: Incremental value of ^{131}I-SPECT/CT in the management of patients with differentiated thyroid carcinoma. J Nucl Med 2008;49:1952–1957.

19 Wong KK, et al: Incremental value of diagnostic ^{131}I SPECT/CT fusion imaging in the evaluation of differentiated thyroid carcinoma. AJR Am J Roentgenol 2008;191:1785–1794.