**Society of Nuclear Medicine and Molecular Imaging Procedure Standard for Scintigraphy for Differentiated Thyroid Cancer**

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**PREAMBLE**

The Society of Nuclear Medicine and Molecular Imaging (SNMMI) is an international scientific and professional organization founded in 1954 to promote the science, technology, and practical application of nuclear medicine. Its 18,000 members are physicians, technologists, and scientists specializing in the research and practice of nuclear medicine. In addition to publishing journals, newsletters, and books, the SNMMI also sponsors international meetings and workshops designed to increase the competencies of nuclear medicine practitioners and to promote new advances in the science of nuclear medicine. The European Association of Nuclear Medicine (EANM) equally is an international scientific and professional organization promoting the nuclear medicine with about 3,500 members specializing in the research and practice of nuclear medicine. The EANM was founded in 1985.

The SNMMI/EANM will periodically define new procedural recommendations for nuclear medicine practice to help advance the science of nuclear medicine and to improve the quality of service to patients. Existing practice guidelines will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

Each procedural recommendation, representing a policy statement by the SNMMI/EANM, has undergone a thorough consensus process in which it has been subjected to extensive review. The SNMMI/EANM recognizes that the safe and effective use of diagnostic nuclear medicine imaging requires specific training, skills, and techniques, as described in each document.

These procedural recommendations are an educational tool designed to assist practitioners in providing appropriate care for patients. They are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care. For these reasons and those set forth below, the SNMMI and the EANM caution against the use of these procedural recommendations in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the physician in light of all the circumstances presented. Thus, an approach that differs from the procedural recommendations, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in the procedural recommendations when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations of available resources, or advances in knowledge or technology subsequent to publication of the procedural recommendations.

The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. Therefore, it should be recognized that adherence to these procedural recommendations will not ensure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The sole purpose of these procedural recommendations is to assist practitioners in achieving this objective.

**I. INTRODUCTION**

Surgical histopathology, diagnostic and post-therapy radioiodine (RAI) scintigraphy, and post-operative thyroglobulin (Tg) provide information contributing to differentiated thyroid cancer (DTC) staging, risk stratification, and clinical management. The purpose of this document is to provide the procedure standard on the RAI scintigraphy aspect of DTC management. The addition of SPECT/CT to planar RAI imaging has been shown to reduce equivocal findings and improve staging in these patients.

**II. GOALS**

The goal of this procedure standard is to assist nuclear medicine practitioners in recommending, performing, interpreting, and reporting the results of scintigraphy for DTC.

**III. DEFINITIONS**

*Radioactive iodine (RAI)* is taken up by functioning benign or malignant thyroid tissue based upon sodium-iodide symporter (NIS) expression.

*RAI scintigraphy* with 131I NaI or 123I NaI can be performed after total thyroidectomy and before RAI ablation, after therapeutic 131I NaI administration, or as surveillance for identification and localization of regional and distant DTC metastases. The typical images acquired are planar anterior and posterior whole-body along with spot views of the neck and chest and with additional SPECT/CT as clinically indicated.

*Radiotheranostics* for thyroid cancer integrates diagnostic imaging and therapeutic radionuclides with 131I NaI being the classic example of a radiotheranostic agent for this purpose. This document focuses on the imaging aspect of this equation.

*Thyroglobulin (Tg)* is a dimeric protein produced by the follicular cells of the thyroid gland, can be elevated in residual thyroid tissue, and is used as a DTC tumor marker after total thyroidectomy and post-operative thyroid remnant ablation.

*Tg antibody* is a class G immunoglobulin and can also be elevated in recurrent thyroid cancer.

*18F-FDG positron emission tomography (FDG-PET)* may be helpful for detecting recurrent thyroid cancer in cases of a rising serum Tg and negative radioiodine imaging.

**IV. COMMON CLINICAL INDICATIONS**

The common clinical indication for utilizing thyroid scintigraphy as outlined here is for the detection of the presence of and localization of any functioning residual, recurrent, or metastatic DTC. This includes patients shortly after thyroidectomy and prior to or after 131I NaI treatment of iodine-avid tissue as well as for any surveillance.

**V. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL**

1. **Physician**

Scintigraphic imaging for DTC should be performed under the supervision of a physician specialized in nuclear medicine and certified by the appropriate board.

1. **Technologist**

Scintigraphic imaging for DTC should be performed by a qualified registered or certified Nuclear Medicine technologist. Refer to the *Responsibility and Guidelines for the Nuclear Medicine Technologist* for further details.

1. **Medical Physicist**

The medical physicist should be involved in protocol/image acquisition and processing as necessary including as recommended by the manufacturer.

**VI. PROCEDURE**

Also see the SNMMI Procedure Standard for General Imaging.

1. **Study Requisition and Appropriateness**

The requisition should include all clinical information about the patient necessary for correct coding of the study. The requisition should also indicate the ability of the patient to cooperate, if there is need for mild sedation or analgesia, and whether the patient needs to be accompanied by a guardian. The exam request should be reviewed by the Nuclear Medicine staff and as needed by the Nuclear Medicine physician for appropriateness. The patient should also be contacted by the Nuclear Medicine department for any pre-scan instructions (i.e., low iodine diet), to give general information regarding the requested Nuclear Medicine procedure (i.e., fasting requirements, laboratory to assess pregnancy status, anticipate length of study), and to establish a doctor/patient relationship.

**B. Patient Preparation**

Avoid materials that can interfere with uptake of 131I NaI or 123I NaI: The concentration of radioiodine in functioning benign or malignant thyroid tissue is affected by many interfering factors, and imaging should be delayed for a period long enough to eliminate their competing effects.

* *Medications/drugs that may interfere with RAI uptake*: Common interfering medications with recommended withdrawal times prior to RAI administration are listed in Table 1.
* *Iodine-containing food and supplements*: Optimal preparation for RAI scintigraphy includes a 1 to 2 week low-iodine diet with the goal of minimizing competitive inhibition by stable alimentary iodide (127I). This is to ensure proper uptake of the radiopharmaceutical by functioning thyroid tissue and to increase imaging sensitivity. Kelp, certain multivitamins, and products made with red food dye number 3 are examples of common iodine-containing ingestible products. A simple practical method of confirming that a low-iodine diet has been followed is by performing a random spot urine iodine measurement (US adult population reference range: 26–705 mcg/L). A level < 100 mcg/L is considered *adequate* preparation, and < 50 mcg/L is considered *optimal* preparation for RAI scintigraphy for DTC. A morning urine specimen provides the most adequate evaluation of recent dietary iodine intake.
* *Intravenous (IV) contrast*: Water-soluble iodinated IV contrast must be avoided for 3-4 weeks prior to RAI administration.

Optimize TSH levels: Appropriately elevated TSH levels at the time of postoperative RAI scintigraphic evaluation and therapeutic 131I NaI administration are required for increasing the NIS expression in metastatic lesions (and residual thyroid tissue) resulting in increased diagnostic sensitivity of RAI scintigraphy and increased radiation absorbed dose to target lesions. TSH levels ≥ 30 mIU/L (measured 1-3 days prior to RAI administration) are considered adequate and can be achieved by either a thyroid hormone withdrawal (THW;(hypothyroid status) or recombinant human TSH (rhTSH) stimulation during levothyroxine (L-T4) therapy (euthyroid status).

* *THW:* This consists of L-T4 deprivation for 4 weeks or triiodothyronine (T3) treatment for 4 weeks with subsequent T3 discontinuation for 2 weeks prior to RAI scintigraphy.
* *rhTSH stimulation:* Thisconsists of administration of rhTSH given as two intramuscular (IM) injections of 0.9 mg on each of two consecutive days with RAI or FDG given the next day. rhTSH may be required if the patient cannot be prepared by near-total thyroidectomy, in patients with significant comorbidities in whom prolonged hypothyroidism would represent a risk or cannot be tolerated, in patients with pituitary insufficiency, or those with isolated TSH deficiency.
* *Side effects:* The patient should be informed of the potential side effects of rhTSH injection and of hypothyroidism from THW. In order to avoid severely symptomatic, prolonged hypothyroidism, patients may be maintained on T3 until 10–14 days prior to administration of RAI.
* *Considerations for the TSH optimization preparation:* The choice of preparation method (THW vs. rhTSH) is a very complex issue and needs to be individualized for each patient. Important considerations include:
* There is agreement that for normal thyroid tissue (i.e. thyroid remnant), rhTSH and THW stimulation are equivalent, because normal thyroid tissue has constitutive high expression of highly functional Na-I symporters and does not require prolonged TSH stimulation for adequate RAI uptake and retention.
* However, metastatic thyroid cancer has lesser density and poorer functionality of Na-I symporters, and therefore, TSH elevation over time (area under the curve of TSH stimulation) is important to promote increased RAI uptake and retention in tumors. Across 2 clinical studies, rTSH-stimulated scans failed to detect remnant and/or cancer localized to the thyroid bed in 17% of patients and metastatic disease in 29% in whom it was detected by a scan after L-T4 withdrawal. (Thyrogen package insert)
* The level of Tg elevation after rhTSH stimulation is 3-5 times less than that obtained after THW which may result in suboptimal evaluation of post-operative disease burden.

Additional lab values:

* *TSH and Tg:* If the patient has undergone THW, TSH and Tg values should be obtained 1-3 days before a diagnostic RAI dose. Knowledge of TSH-stimulated Tg levels is very useful, especially in interpreting negative scintigraphic findings. Typically, a Tg level of < 1.0 ng/ml indicates remission, while a level < 10 indicates persistent disease. For the rhTSH protocol, Tg should be evaluated at baseline (prior to rhTSH administration) and at 3 days after the 2nd dose of rhTSH.
* *Anti-Tg Antibody:* Anti-Tg antibody can falsely elevate or lower Tg levels invalidating the serum Tg measurement. Therefore, Tg antibody assays must also be obtained in tandem with Tg testing.

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| **SUMMARY OF INFORMATION PERTINENT TO PERFORMING THE PROCEDURE** |
| Avoidance and history of radioiodine interfering materials (e.g., medications, IV contrast (especially as part of a CT examination)) |
| Compliance with low-iodine diet |
| Appropriate TSH level |
| Preparation with thyroid hormone withdrawal versus rhTSH |
| Blood sample obtained for Tg and anti-Tg antibody level |
| Surgical information (e.g., total/subtotal thyroidectomy vs. lobectomy, extent of cervical compartments dissected) |
| Histopathology (presence/absence of capsular and/or angiolymphatic invasion, extrathyroidal extension, surgical margin status, presence/extent of lymph node metastases, and level of cervical compartments involved) |
| Results of prior scintigraphy and/or other pertinent imaging procedures |
| History of any prior RAI treatment |
| Physical examination findings |
| Menstrual and lactation history, negative serum pregnancy test prior to RAI administration |

**C. Precautions/Contraindications**

Pregnancy/Breastfeeding:

* *Urine pregnancy test:* On the day of scheduled 131I NaI administration for females 12 – 55 years old, unless there is clear documentation that pregnancy cannot be possible (e.g., previous bilateral oophorectomy)., a urine or serum pregnancy test is recommended in addition to clinical history to verify absence of pregnancy.
* *Pregnancy after RAI administration:* Patients should be advised to avoid pregnancy for at least 6 months after 131I NaI administration.
* *Breastfeeding prior to RAI administration:* To allow for breast tissue involution and minimize 131I NaI uptake and radiation absorbed dose to the maternal breast as well as to prevent the nursing child from ingesting radioactive breast milk, breastfeeding should be discontinued for at least 6 weeks (but preferably for 3 to 6 months) prior to RAI administration.
* *Breastfeeding after RAI administration:* After I131 NaI administration, breastfeeding must be discontinued. It can be resumed after the birth of another child. If 123I NaI is given, breastfeeding can be resumed 72 hours later. For FDG, breastfeeding should be discontinued for 4 hours.

1. **Radiopharmaceuticals and Dosage**

The following are recommended diagnostic imaging dosages:

Oral 131I NaI: For diagnostic imaging, 37-148 MBq (1–4 mCi) is given with many preferring a range of 37-74 MBq (1–2 mCi) because of data suggesting that stunning (decreased uptake of the therapy dose of 131I NaI by residual functioning thyroid tissue and/or tumor due to cell death or dysfunction caused by the activity administered for diagnostic imaging) is less likely at the lower administered activity. However, stunning may not influence the outcome of treatment. The method of TSH stimulation also needs to be considered in deciding the activity employed for diagnostic 131I NaI scintigraphy, usually as: 37-74 MB1 (1-2 mCi) if the patient is hypothyroid and 111-148 MBq (3-4 mCi) if a rhTSH stimulation protocol was followed. There is no consensus practice parameter for weight-based administration for children.

Oral 123I NaI: The typical administered dosage for diagnostic imaging is between 74-148 MBq (2-4 mCi). There is no consensus practice parameter for weight-based administration for children.

18F-FDG: The typical administered dosage for oncology is 370-740 MBq (10-20 mCi). FDG may be used to identify tumors that are not detected with RAI. These are usually less well-differentiated tumors (FDG-positive, radioiodine-negative) and are less likely to respond to 131I NaI treatment. These tumors may be more aggressive, have a less favorable prognosis, and may be amenable to surgical resection, external radiation, or embolization. Imaging with FDG is more sensitive when the serum TSH is elevated (THW or rhTSH stimulation).

**E. Imaging**

Clinical Settings for Imaging:

* *Post-Thyroidectomy, Pre-RAI Ablation Imaging*: Nuclear medicine physicians are divided as to the need for pre-ablation imaging. The American Thyroid Association (ATA) guidelines recommend that a postoperative diagnostic RAI scan may be useful when the extent of the thyroid remnant or residual disease cannot be accurately ascertained from the surgical report or neck ultrasonography and when the results may alter the decision to treat or the activity of RAI that is to be administered. Despite differing practices regarding pre-ablation diagnostic RAI imaging, one must recognize that the following may be uncovered and/or useful:
* Diagnostic RAI scintigraphy may reveal unexpected iodine-avid metastatic disease in 22% - 35% cases and change management in approximately 30% - 50% cases as compared to an imaging strategy which does not include diagnostic scintigraphy.
* Approximately 1% of the time, the thyroidectomy is truly total, and if there are no remnants or other foci of iodine-avid tissue on the scan, then giving radioiodine would not be indicated. However, in high-risk patients, treatment of occult metastases may be warranted.
* The scan is useful in helping to determine the 131I NaI dosage for ablation or therapy. Larger therapeutic RAI activities are usually given for ablation if regional or distant metastases are detected on the pre-ablation scan.
* Distant metastases in the brain or spinal cord may require pre-radiation corticosteroids to avoid complications caused by radiation-induced swelling.
* Identification and localization of abnormal foci on planar imaging may be enhanced by concomitant SPECT/CT imaging.
* *Post-Thyroidectomy, Post-RAI Ablation Imaging*
* *Post-Thyroidectomy/Post-RAI Ablation Imaging for Surveillance:* Scintigraphy for surveillance is tailored per the risk stratification of the patient and is an ongoing dynamic process. In general, a low risk patient may not require surveillance, but it is recommended for intermediate to high-risk for recurrent DTC and for those with rising Tg levels and a negative cervical ultrasound.

Instrumentation:

* *131I NaI:* A large field-of-view dual-head gamma camera fitted with a high-energy parallel-hole collimator is used. A 15-20% window is centered on the 364 keV photopeak.
* *123I NaI:* A low- or medium-energy collimator is used depending upon the manufacturer’s specifications. A 15-20% window is centered on the 159 keV photopeak.
* *FDG:*  Follow a usual PET/CT oncology protocol.

Patient Maneuvers:

* *Clearance of confounding physiologic activity:* The patient should drink a large glass of water and/or chew and swallow crackers before each set of images to clear physiologic pharyngeal and/or esophageal activity.
* *Imaging position:* The patient should lie supine on an imaging table with the neck slightly extended. Include the chin and arms in the field-of-view.

Timing:

* *131I NaI*: Pre-ablation and surveillance images are obtained between 24 and 72 hours after RAI administration (24-hour images may not have clearly-defined activity, thus the patient may need to be brought back at 48 to 72 hours to improve lesion detection repeat imaging to allow an improved target to background ratio). Post-RAI ablation images can be obtained 2 to 7 days after treatment.
* *123I NaI:* Pre-ablation or surveillance images are obtained 6 to 24 hours after administration of this radiopharmaceutical. Some prefer 123I NaI as images are of higher quality than with 131I NaI and stunning may be prevented, but cost and/or availability may be a limiting factor for 123I.
* *FDG*: Images are acquired approximately 60 minutes following injection of the radiopharmaceutical. When there is suspicion that the 131I NaI scan will be negative or have low sensitivity, an FDG scan should be performed while TSH levels are elevated (THW or rhTSH protocol).

Acquisition:

* *Whole-body scan:* Anterior and posterior planar parallel-hole collimator gamma camera images from the top of the skull through the femurs are obtained with a scan speed of 8 cm/min to 10 cm/min with a 256 x 256 matrix. Longer acquisition times may be helpful for images obtained more than 3 days after administration of 131I NaI. A 256 x 1024 matrix may be used for I123 NaI.
* *Spot images:* Static images should be acquired for 20 minutes using a 256 x 256 matrix per view to include the nasopharynx, thyroid bed, and/or chest. These images may improve lesion detection.
* *Pinhole images:* Further pinhole images of selected areas may be acquired as deemed necessary for single photon emitters. These images may improve lesion detection.
* *Markers:* In the neck, radioactive anatomic markers may be helpful in differentiating between normal residual thyroid tissue, salivary gland uptake, residual thyroid cancer, and lymph node metastasis.
* *SPECT/CT:* This is helpful for more accurate anatomic lesion localization and especially for identifying lymph nodes in the neck, differentiating mediastinal versus lung uptake, and/or evaluating for bone metastases. SPECT/CT is preferred over planar imaging to anatomically localize concerning areas of uptake seen on the whole-body RAI scan. One study has shown that diagnostic RAI scans with SPECT/CT performed after total thyroidectomy detected regional metastases in 35% of patients and distant metastases in 8%. This resulted in a change in clinical management in approximately 30% of patients as compared to a management strategy based upon surgical pathology alone. If available, SPECT/CT imaging should be performed with an axial field of view extending from the skull base to the diaphragm. In addition, all foci of abnormal activity seen on planar images outside the neck and chest which do not conform to a physiological distribution should be further evaluated with SPECT/CT. The patient is imaged with arms down and without immobilizers. Imaging is performed on a hybrid dual-head gamma camera with an inline CT scanner.

Recommended SPECT image parameters:

* 64 projections
* 128 x 128 matrix
* 20 seconds/projection
* non-circular orbit over 360 degrees

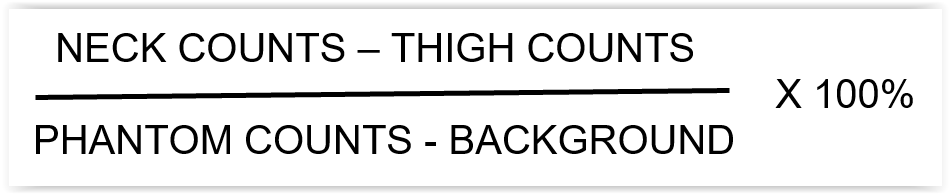
Tomographic images are reconstructed using 3D OSEM iterative reconstruction (8 iterations, 4 subsets), and a CT-based attenuation correction algorithm was applied.

Recommended CT image parameters:

* 130 kVp
* 80 mAs,
* 3 mm collimation
* 0.8 pitch

CT reconstruction is performed at 5 mm slice thickness into a 512 x 512 matrix.

* *Flood source*: An image obtained with a flood source may be considered to outline body contour.
* *24-Hour Neck Uptake/Residual Fraction:* Quantitative measurement of RAI uptake (RAIU) in the neck is often helpful in determining the mass of remaining thyroid tissue or tumor and is usually acquired at 24 hours after administration of 123I NaI or 131I NaI. The desired value after near total or total thyroidectomy is 0.5 – 5%. The technique is as follows:
* Uptake is typically measured with 25–30 cm between the face of the crystal and the area(s) of interest.
* One example amongst variable techniques using an uptake probe and software is as follows. Acquire counts for 1 minute for each of the following: over the thyroid bed, patient’s thigh (body background), room background, and a calibrated standard (radiopharmaceutical source identical to that administered to the patient) contained in a neck phantom.
* The 24-hour RAIU can then be calculated as:



* *FDG-PET/CT:* Follow the usual PET/CT oncology protocol. Acquisition should be in the 3D mode.

**F. Interpretation Criteria**

Physical Examination: An adequate physical examination and history should be obtained. Palpable soft tissue in the neck should be correlated with scintigraphic findings.

Thyroid Bed Activity: Particular attention should be paid to any activity in the thyroid bed. Planar images may not differentiate between thyroid bed residual normal thyroid tissue (i.e. thyroid remnants) versus thyroid malignancy. Lateral and oblique planar views and/or preferably SPECT/CT may be useful in this case to help separate thyroid bed activity from adjacent lymph node activity.

Image Correlation: Findings on physical examination and scintigraphy should be correlated with any additional imaging if available (i.e. CT, MR, US, other nuclear medicine studies).

**VII. DOCUMENTATION/REPORTING**

For general recommendations on all nuclear medicine reports, see the *SNMMI Procedure Standard for General Imaging and the American College of Radiology Practice Guideline for Communication: Diagnostic Radiology*.

**A. Indications**

The report should briefly summarize the reason for the examination, pertinent medical or surgical history, and the results of any relevant laboratory tests or prior imaging studies.

**B. Technique**

The report should include the name of the radiopharmaceutical administered, the dosage, and the scanning protocol.

**C. Findings**

The report should include the location and character of any abnormal uptake, comparison with the results of prior imaging studies (if pertinent or available), and any pertinent additional CT findings (if CT was performed with SPECT). If obtained, the quantitative 24-hour 123I NaI/131I NaI uptake value should also be reported along with a qualitative estimate of the size, activity, and location of any areas of uptake that correspond to any functioning normal or abnormal thyroid tissue.

**D. Impression**

The impression should include conclusions, diagnoses, or differential diagnoses to answer questions posed by the referring clinician or team or to answer any unexpected findings, any recommendations for further work-up.

**VIII. QUALITY CONTROL AND IMPROVEMENT**

See the SNMMI Procedure Standard for General Imaging for general recommendations.

1. **Possible Sources of Error**

* Local contamination (clothing, skin, hair, collimator, imaging table)
* Esophageal activity
* Asymmetric salivary gland uptake
* Breast uptake
* Thymic uptake
* Ectopic thyroid tissue
* Uptake by non-thyroid neoplasms
* Inadequate patient preparation

**IX. SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION CONCERNS**

See the SNMMI Procedure Standard for General Imaging for general recommendations.

**X. RADIATION SAFETY IN IMAGING**

See the SNMMI Procedure Standard for General Imaging for general recommendations. It is the position of SNMMI that exposure to ionizing radiation should be at the minimum level (ALARA - as low as reasonably achievable) needed to obtain a diagnostic examination. Radiation dosimetry for adults is presented in Table 2.

**XI. ACKNOWLEDGEMENTS**

The Committee on SNMMI Procedure Standards consists of the following individuals: ………………..

**XII. BIBLIOGRAPHY**

1.ACR practice guidelines for imaging pregnant or potentially pregnant adolescents and women with ionizing radiation. 2018. <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/Pregnant-Pts.pdf?la=en>. Last accessed 2-14-19.

2.ACR–SPR technical standard for diagnostic procedures using radiopharmaceuticals. 2016.

3.Avram AM. Radioiodine scintigraphy with SPECT/CT: an important diagnostic tool for staging and risk stratification. In: Thyroid Cancer: A Comprehensive Guide To Clinical Management*.* 3rd ed. New York, NY: Springer; 2016:215-23.

4.Avram AM, Fig LM, Frey KA, et al. Preablation 131I scans with SPECT/CT in postoperative thyroid cancer patients: what is the impact on staging? *J Clin Endocrinol Metab*. 2013; 98; 1163-7.

5.Balon HR, Meier DA, Charkes ND, Royal HD, Sarkar SD, Donohoe KJ. Society of Nuclear Medicine procedure guidelines for thyroid uptake measurement version 3.0. 2006.

6.Baum, RP. Therapeutic Nuclear Medicine. 2014. Springer.

7.Chen S, Li N, Li X, et al. 74 MBq 131I for diagnostic scan can decrease the uptake of 131I by thyroid remnants or metastases, the thyroid stunning exists. *Q J Nucl Med Mol Imag*. 2015; 59:455-61.

8.Chin BB, Patel P, Cohade C, et al. Recombinant human thyrotropin stimulation of fluoro-D-glucose positron emission tomography uptake in well-differentiated thyroid carcinoma. *J Clin Endocrinol Metab*. 2004; 89:91–5.

9.Choi SJ, Jun KP, See SS, et al. Clinical usefulness of F-18 FDG PET/CT in papillary thyroid cancer with negative radioodine scan and elevated thyroglobulin level or positive anti-thyroglobulin antibody. *Nucl Med Mol Imaging*. 2016; 50: 130-6.

10. Dilsizian V, Metter D, Palestro C, et al. Advisory committee on medical uses of isotopes (ACMUI) sub-committee on nursing mother guidelines for the medical administration of radioactive materials. 2019.

11.Haugen BR, Alexander EK, Bible KC, et al. 2015 American Thyroid Association management guidelines for patients with thyroid nodules and differentiated thyroid cancer: The American Thyroid Association guidelines task force on thyroid nodules and differentiated thyroid cancer. *Thyroid*. 2016; 26:1-133.

12.Dam HQ, Kim SM, Lin HC, et al. 131I therapeutic efficacy is not influenced by stunning after diagnostic whole-body scanning. *Radiology*. 2004; 232:527–33.

13.de Geus-Oei L, Oei H-Y, Hennemann G, et al. Sensitivity of 123I whole-body scanning and thyroglobulin in the detection of metastases or recurrent differentiated thyroid cancer. *Eur J Nucl Med*. 2002; 29:768–74.

14.Grant FD, Treves ST. Thyroid. *In: Pediatric nuclear medicine and molecular imaging*. 4th ed. New York, NY: Springer; 2014:99-129.

15.Heston TF, Wahl R. Molecular imaging in thyroid cancer. *Cancer Imaging*. 2010; 10:10-7.

16.ICRP. Radiation dose to patients from radiopharmaceuticals: addendum 3 to ICRP Publication 53—ICRP Publication 106. Approved by the Commission in October 2007. *Ann ICRP*. 2008; 38:1–197.

17. Iwata M, Kasagi K, Misaki T et al. Comparison of whole-body 18F-FDG PET, 99mTc-MIBI SPECT, and post-therapeutic 131I-Na scintigraphy in the detection of metastatic thyroid cancer. *Eur J Nucl Med Mol Imaging*. 2004; 31:491–8.

18.Jo K, Lim DJ. Clinical implications of anti-thyroglobulin antibody measurement before surgery in thyroid cancer. *Korean J Int Med*. 2018. 33:1050-7.

19.Kang SW, Yap ZZ, Lee CR, et al. Pattern of urine iodine excretion with low idodine diet during preparation for radioactive iodine ablation in patients with thyroid cancer. *Head Neck*. 2019; 41:381-7.

20. Kowalska A, Palyga I, Gasior-Perczak D. The cut-off level of recombinant human TSH-stimulated thyroglobulin in the follow-up of patients with differentiated thyroid cancer. *PLoS One.* 2015; 10:

21.Lakshmanan M, Schaffer A, Robbins J, et al. A simplified low-iodine diet in I-131 scanning and therapy of thyroid cancer. *Clin Nucl Med*. 1988; 13:866–8. 209.Li JH, He ZH, Bansal V, et al. Low iodine diet in differentiated thyroid cancer: a review. *Clin Endocrinol*. 2016; 84:3-12.

22.Kulkarni K, Atkins FB, Van Nostrand D. The utility of SPECT-CT in differentiated thyroid cancer. In: *Thyroid cancer: a comprehensive guide to clinical management*. 3rd ed. New York, NY: Springer. 2016: 205-14.

23.Liu H, Wang X, Yang R, et al. Recent development of nuclear molecular imaging in thyroid cancer. *Biomed Research International*. 2018.

24.Liu Y. The role of 18F-FDG PET/CT in the follow-up of well-differentiated thyroid cancer with negative thyroglobulin but positive and/or elevated antithyroglobulin antibody. *Nucl Med Commun*. 2016; 37:577-82.

25.Mazzaferri EL, Amdur RJ. Essentials of Thyroid Cancer Management. 2006. Springer Science and Business Media.

26.McDougall IR. 74 MBq radioiodine 131I does not prevent uptake of therapeutic doses of 131I (i.e. it does not cause stunning) in differentiated thyroid cancer. *Nucl Med Commun*. 1997; 18:505-12.

27.McDougall IR, Iagaru A. Thyroid stunning: fact or fiction? *Seminars Nucl Med*. 2011; 41:105-12.

28.Mettler FA, Guiberteau MJ. Essentials of Nuclear Medicine Imaging. 2018. Elsevier Health Sciences.

29.Padovani RP, Kasamatsu TS, Nakabashi CCD, et al. One month is sufficient for urinary iodine to return to its baseline after the use of water-soluble iodinated contrast agents in post-thyroidectomy patients requiring radioiodine therapy. *Thyroid*. 2012; 22:926-30.

30.Palmedo H, Bucerius J, Joe A. Integrated PET/CT in the differentiated thyroid cancer: Diagnostic accuracy and impact on patient management. *J Nucl Med*. 2006; 47:616-24.

31.Park HM, Park YH, Zhou XH. Detection of thyroid remnant/metastases without stunning: an ongoing dilemma. Thyroid. 1997; 7:277–80.

32.Plotkin M, Hautzel H, Krause BJ, et al. Implication of 2-18fluoro-2-deoxyglucose positron emission tomography in the follow-up of Hurthle cell thyroid cancer. *Thyroid* . 2002; 12:155–61.

33. Prestwich RJ, Viner S, Gerrard G, et al. Increasing the yield of recombinant thyroid-stimulating hormone-stimulated 2-(18-fluoride)-flu-2-doxy-D-glucose positron emission tomography-CT in patients with differentiated thyroid carcinoma. *Br J Radiol*. 2012; 85:e805-13.

34. Robbins RJ, Chon JT, Fleisher M, et al. Is the serum thyroglobulin response to recombinant human thyrotropin sufficient, by itself, to monitor for residual thyroid carcinoma? *J Clin Endocrinol Metab*. 2002; 87:3242-7.

35. Roman SA, Sosa JA, Solorzano CC. Management of Thyroid Nodules and Differentiated Thyroid Cancer. 2017. Springer.

36. Sarkar SD, Kalapparambath TP, Palestro CJ. Comparison of 123I and 131I for whole-body imaging in thyroid cancer. *J Nucl Med*. 2002; 43: 632–4.

37.Sawka AM, Ibrahim-Zada I, Galacgac P, et al. Dietary iodine restriction in preparation for radioactive iodine treatment or scanning in well-differentiated thyroid cancer: a systematic review. *Thyroid*. 2010; 20:1129-38.

38. Sherman SI, Tielens ET, Sostre S, et al. Clinical utility of post-treatment radioiodine scans in the management of patients with thyroid carcinoma. *J Clin Endocrinol Metab*. 1994; 78: 629–34.

39. Shiga T, Tsukamoto E Nakada K, et al. Comparison of 18F-FDG, 131I-Na, and 201Tl in diagnosis of recurrent or metastatic thyroid carcinoma. *J Nucl Med*. 2001; 42:414–9.

40. Sisson JC. Selection of the optimal scanning agent for thyroid cancer. *Thyroid*. 1997; 7: 295–302.

41. Song H, Mosci C, Akatsu H, et al. Diagnostic 123I whole body scan prior to ablation of thyroid remnant in patients with papillary thyroid cancer: implications for clinical management. *Clin Nucl Med*. 2018; 43:705-9.

42. Stangierski A, Kaznowski J, Wolinski K, et al. The usefulness of fluorine-18 fluorodeoxyglucose PET in the detection of recurrence in patients with differentiated thyroid cancer with elevated thyroglobulin and negative radioodine whole body scan. *Nucl Med Commun.* 2016; 37:935-8.

43. Treves ST, Gelfand MJ, Fahey, FH, et al. 2016 update of the north american consensus guidelines for pediatric administered radiopharmaceutical activities. 2016; 57:15N-18N.

44. Urhan M, Dadparvar S, Mavi A, et al. Iodine-123 as a diagnostic imaging agent in differentiated thyroid carcinoma: a comparison with iodine-131 post-treatment scanning and serum thyroglobulin measurement. *Eur J Nucl Med Mol Imaging*. 2007;` 34:1012-7.

45. Walrand S, Hesse M, Jamar F. Statistical and radiobiological analysis of the so-called thyroid stunning. *Eur J Nucl Med Mol Imag*. 2015; 5:67.

46. Wang WW, Larson SM, Fazzari M, et al. Prognostic value of [18F] fluorodeoxyglucose positron emission tomographic scanning in patients with thyroid cancer. *J Clin Endocrinol Metab*. 2000; 85:1107-13.

47. Weibel JL, Esfandiari NH, Papaleonitiou M, et al. Evaluating positrón emissión tomography use in differentiated thyroid cancer. *Thyroid*. 2015; 25:1026-32.

48. Wong KCW, Ng TY, Yu KS, et al. The use of post-ablation stimulated thyroglobulin in predicting clinical outcomes in differentiated thyroid carcinoma – what cut-off values should we use? *Clin Oncol*. 2018. Ahead of print.

49. Wong KK, Gandhi A, Viglianti BL, et al. Endocrine radionuclide scintigraphy with fusion single photon emission computed tomography/computed tomography. *World J Radiol*. 2016; 8:635-55.

50. Yen TC, Lin HD, Lee CH, et al. The role of technetium-99m-sestamibi whole-body scans in diagnosing metastatic Hurthle cell carcinoma of the thyroid gland after total thyroidectomy: a comparison with iodine-131 and thallium-201 whole-body scans. *Eur J Nucl Med.* 1994; 21:980-3.

51. Ziessman HA, O’Malley JP, Thrall JH. Nuclear Medicine: The Requisites. 2013. Elsevier Health Sciences.

52. Zilioli V, Peli A, Panarotto MB, et al. Differentiated thyroid carcinoma: incremental diagnostic value of 131I SPECT/CT over planar whole-body scan after radioiodine therapy. *Endocrine. 2017; 56:551-9.*

**XII. APPROVAL**

The Board of Directors of the SNMMI approved version \_\_\_\_\_ at the SNMMI Annual Meeting in June \_\_\_\_\_\_.

|  |  |
| --- | --- |
| **TABLE 1: Representative Drugs/Supplements That Interfere With Radioiodine** | |
| (in alphabetical order) | |
| *Name* | *Withdrawal Time* |
| Amiodarone | 3-6 months |
| Antitussives | 2-4 weeks |
| Bromides | 1 week |
| Iodinates Ointments | 2-4 weeks |
| Levothyroxine (T4) | 4-6 weeks |
| Lugol's Solution | 2-3 weeks |
| Mineral/Vitamin Supplements | 2-4 weeks |
| Nitrates | 1 week |
| Perchlorate | 1 week |
| Potassium Iodide | 2-3 weeks |
| Salicylates (large doses) | 1 week |
| Steroids | Variable |
| Sulfonamides | 1 week |
| Triiodothyronine (T3) | 2-3 weeks |

**TABLE 2**

**Radiation Dosimetry for Adults**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Radiopharmaceuticals** | **Administered** | **Organ Receiving the** | **Effective Dose** |  |
|  | **Activity** | **Largest Radiation Dose** |  |  |
|  | **MBq** | **mGy/MBq** | **mSv/MBq** |  |
|  | **(mCi)** | **(rad/mCi)** | **(rem/mCi)** |  |
| 18F-fluorodeoxyglucose | 370–740 IV | 0.15 | 0.019 |  |
|  | (10-20) | bladder wall |  |  |
|  |  | (0.56) | (0.07) |  |
| Na123I iodide | 74–148 PO | 0.097 | 0.010 |  |
| (0% thyroid uptake) | (2-4)c | bladder wall |  |  |
|  | (0.36) | (0.039) |  |
| Na131I iodide | 37–148 PO | 0.66 | 0.058 |  |
| (0% thyroid uptake) | (1–4)c | bladder wall |  |  |
|  | (2.4) | (0.21) |  |

1. <https://www.doseinfo-radar.com> Accessed 6-16-19.
2. International Commission on Radiological Protection. Radiation Doses to Patients from Radiopharmaceuticals. Elsevier. 2008.
3. Delbeke D, Coleman RE, Guiberteau MJ, et al. Procedure guideline for tumor imaging with 18F-FDG PET/CT 1.0. *J Nucl Med* 2006;47:885–895.