Society of Nuclear Medicine Procedure Guideline for Thyroid Uptake Measurement

Version 3.0, approved September 5, 2006

Authors: Helena R. Balon, MD, Chair (William Beaumont Hospital, Royal Oak, MI); Edward B. Silberstein, MD (University of Cincinnati Medical Center, Cincinnati, OH); Donald A. Meier, MD (William Beaumont Hospital, Royal Oak, MI); N. David Charkes, MD (Temple University Hospital, Philadelphia, PA); Henry D. Royal, MD (Mallinckrodt Institute of Radiology, St. Louis, MO); Salil D. Sarkar, MD (Jacobi Medical Center, Bronx, NY); Kevin J. Donohoe, MD (Beth Israel Deaconess Medical Center, Boston, MA)

I. Purpose

The purpose of this guideline is to assist nuclear medicine practitioners in recommending, performing, interpreting and reporting the results of thyroid uptake measurements.

II. Background Information and Definitions

Thyroid uptake determination is the measurement of the fraction of an administered amount of radioactive iodine that accumulates in the thyroid at selected times following ingestion. Alternatively, thyroid uptake can be determined, less accurately, using intravenously administered ^{99m}Tc-pertechnetate and a gamma camera.

In this document, hyperthyroidism refers to an excess of circulating thyroid hormones.

III. Examples of Clinical or Research Applications

A. Guidance in determining the activity of ^{131}I to be administered to patients for therapy of hyperthyroidism due to Graves' disease and toxic nodular goiter. The uptake measurement should be performed as close in time as possible to the treatment.

B. Differentiation of subacute or painless thyroiditis and factitious hyperthyroidism from Graves' disease and other forms of hyperthyroidism.

C. Confirmation of the diagnosis of hyperthyroidism due to Graves' disease.

D. Note: Measurement of uptake is of limited value in diagnosing hypothyroidism.

IV. Procedure

A. Patient Preparation

1. Avoidance of interfering materials

   The concentration of radioiodine in the thyroid is affected by many factors such as:

   a. Medications such as thyroid hormones and antithyroid drugs.

   b. Iodine-containing food (eg, kelp) and medications (eg, iodinated contrast, amiodarone, betadine).

   Uptake measurement should be delayed for a period long enough to eliminate the effects of these interfering factors. (As a general guideline, antithyroid drugs should be withheld for 2–4 d, T4 therapy for 4–6 wks, T3 therapy for 2 wks. Uptake should be measured no sooner than approximately 2–4 wks after water-soluble iodinated contrast. The effect of amiodarone may persist for 6 months or longer.)

   A low-iodine diet for 7–14 d before the radioiodine is often employed when uptake is used before large therapeutic doses for thyroid cancer.

2. Large meals can slow absorption of ingested radioiodine and may interfere with early uptake measurements; therefore, the patient should avoid meals for at least 2 h before and 2 h after the oral dose of radioiodine if an early uptake is planned.

A. Information Pertinent to Performing the Procedure

1. History of interfering medications (eg, thyroid hormone, antithyroid drugs, iodine containing medications)

Radiation Dosimetry for Adults

Radiopharmaceutical	Administered Activity MBq (mCi)	Organ Receiving the Largest Radiation Dose mGy/MBq (rad/mCi)	Effective Dose Equivalent mSv/MBq (rem/mCi)
NaI-123 iodide*	3.7–11.1 po (0.1–0.3)	3.2 Thyroid (12.0)	0.11 (0.41)
^{99m}Tc-pertechnetate	74–370 iv (2–10)	0.062 ULI** (0.23)	0.013 (0.048)
Na^{131}I iodide*	0.15–0.37 po (0.004–0.01)	360 Thyroid (1300)	11 (41.0)

* assuming 25% uptake

** ULI—upper large intestine

References:

1. Michael G. Stabin, PhD, CHP: Radiation Internal Dose Information Center, Oak Ridge Institute for Science and Education, Oak Ridge, TN, 1996.
2. ICRP Publication 53, Radiation Dose to Patients from Radiopharmaceuticals, 1994 edition.
3. Loevinger R, Budinger T, Watson, E: MIRD Primer for Absorbed Dose Calculations, Society of Nuclear Medicine, 1991.

2. Exposure to iodinated contrast
3. Ingestion of iodine-rich foods
4. Pertinent laboratory data including the results of thyroid function tests
5. Pregnancy/nursing status
   Postponing administration of ^{131}I to lactating women until 6 or more weeks following cessation of lactation may decrease the radiation dose to the breast. Breast-feeding following the administration of ^{131}I should be stopped to prevent an unnecessary radiation dose to the infant.
6. Results of prior thyroid imaging tests
7. Results of prior thyroid uptake measurement
8. Recent administration of other radionuclides

C. Precautions

Prolonged discontinuation of thyroid or antithyroid medications may be hazardous in some patients.

D. Radiopharmaceutical

1. Radioiodine is generally preferred.
2. Uptakes may be performed in conjunction with ^{99m}Tc-pertechnetate thyroid imaging. Careful validation of this technique is required.

E. Data Acquisition

1. Instrumentation
   A sodium iodide (NaI) crystal uptake probe with suitable lead shielding and a flat field collimator should be used. This is usually integrated with a multiple channel analyzer and recording computer.
2. Measurement of Uptake
   a. The measurement of thyroid uptake is usually performed 18–24 hr after administration of the radioiodine. In some circumstances, it may be performed between 2 and 6 hr after radioiodine ingestion, as well.

      The uptake is usually measured with 25–30 cm between the face of the crystal and the anterior neck or phantom. Neck counts, lower thigh counts (body background), counts of a calibrated standard in a neck phantom and room background counts are preferably obtained at each counting session. Alternatively, the radioiodine dose can be counted in the neck phantom before oral administration, and the counts obtained can be corrected for decay at each patient counting session.

      The ORINS, IAEA or a comparable neck phantom is recommended.

b. Thyroid uptake can alternatively be measured using a scintillation camera, LEAP collimator and appropriate regions of interest. Validation of gamma camera techniques by comparison with a reliable standard is recommended. This technique may also be combined with extended whole-body radioiodine imaging to measure uptake in thyroid remnants following surgery for differentiated thyroid cancer.

F. Interventions

None

G. Processing

Radioiodine uptake (RAIU) is calculated using the following equation:

$$\text{RAIU} = \frac{\text{Neck Counts (cpm)} - \text{Thigh Counts (cpm)}}{\text{Admin. Counts (cpm)} - \text{Background Counts (cpm)}} \times 100\%$$

Administered counts are obtained either by counting the tracer actually administered to the patient or by counting a standard (equivalent to the administered dose) in a neck phantom, with correction for decay if necessary.

H. Interpretation Criteria

Reference values for thyroid uptake determinations must be obtained from the older literature, since it is not possible for each facility to determine contemporary values for radioiodine uptake in euthyroid individuals. In the literature, the normal range of values is usually given as between 10 and 35% for 24-hr uptake, and between 6 and 18% for 4-hr uptake. These values must be interpreted loosely, since they were determined with a variety of equipment, standards, uptake phantoms, and in individuals from populations with various levels of iodine intake, which may not be directly comparable to the patients under study.

The primary usefulness of the radioiodine uptake measurement is to differentiate Graves' hyperthyroidism from that caused by subacute or painless thyroiditis or factitious hyperthyroidism. The diagnosis of hyperthyroidism or hypothyroidism is made with measurements of serum thyroid hormones and TSH levels. Thus this procedure is of relatively little value in the diagnosis of hypothyroidism.

The uptake value is susceptible to a variety of interfering medications and materials, most of which act to lower the uptake. Therefore, a higher

Radiation Dosimetry for Children (5 year old)

Radiopharmaceutical	Administered Activity MBq (mCi)	Organ Receiving the Largest Radiation Dose mGy/MBq (rad/mCi)	Effective Dose Equivalent mSv/MBq (rem/mCi)
$Na^{123}I$ iodide*	3.7–7.4 po	16 Thyroid	0.54
	(0.1–0.2)	(59)	(2.0)
^{99m}Tc-pertechnetate	37–185 iv	0.21 ULI**	0.04
	(1–5)	(0.78)	(0.15)
$Na^{131}I$ iodide* (usually not used in children)	0.15–0.37 po	1900 Thyroid	56
	(0.004–0.01)	(7000)	(21.0)

* assuming 25% uptake

** ULI—upper large intestine

References:

1. Michael G. Stabin, PhD, CHP: Radiation Internal Dose Information Center, Oak Ridge Institute for Science and Education, Oak Ridge, TN, 1996.
2. ICRP Publication 53, Radiation Dose to Patients from Radiopharmaceuticals, 1994 edition.
3. Loevinger R, Budinger T, Watson, E: MIRD Primer for Absorbed Dose Calculations, Society of Nuclear Medicine, 1991.

uptake generally carries more clinical significance than a lower uptake. Radioiodine uptake in toxic nodular goiter is generally lower than in hyperthyroidism of Graves' disease.

Interpretation of the results therefore requires some knowledge of the history and laboratory data, as well as a physical examination. The medication history is of particular importance, and efforts should be made to ensure that the patient is not ingesting iodine-containing materials, thyroid hormone or antithyroid drugs, all of which can influence the radioiodine uptake. The actual time of ingestion of the last such medication is also of significance in evaluating the uptake results.

I. Reporting

Reports should indicate the thyroid uptake, as well as the generally accepted normal range. Variations in uptake should be discussed in the context of the factors outlined above. Variations in uptake value itself do not diagnose the level of function of the thyroid (ie, more or less hyperthyroid), but must be seen in the context of many different factors including iodine content of diet, history, medications, etc.

J. Quality Control

1. Energy spectrum of the MCA (multiple channel analyzer) should be evaluated at least annually.
2. The probe sensitivity (cpm/mCi) should be determined at regular intervals depending on frequency of use and manufacturer's recommendations.
3. Measurement of a long-lived check source using reproducible geometry should be performed each day of use for constancy and accuracy.

K. Sources of Error

1. Variations in neck to detector distance
2. Inappropriate neck phantom
3. Improper centering of the probe over the patient's neck
4. Electronic instability
5. Background variation
6. Interfering food/medications
7. Contamination of the neck phantom
8. Recent administration of other radionuclide
9. Radioactivity in an adjacent area

V. Issues Requiring Further Clarification

None.

VI. Concise Bibliography

A. Chervu S, Chervu L, Goodwin PN, et al. Thyroid uptake measurements with 123I: problems and pitfalls: concise communication. *J Nucl Med* 1982; 23: 667–670.

B. Floyd JL, Rosen PR, Borchert RD, et al. Thyroid uptake and imaging with iodine-123 at 4–5 h: replacement of the 24-h iodine-131 standard. *J Nucl Med* 1985;26:884–887.

C. Hine GJ, Williams JB. Thyroid radioiodine uptake measurements. In: Hine GJ, ed. *Instrumentation in nuclear medicine.* New York: Academic Press; 1967; 1:327–350.

D. McDougall IR. The importance of obtaining thyroid uptake measurement in patients with hyperthyroidism. *Nucl Med Commun* 1990;11:73–76.

E. Meier DA, Kaplan MM. Radioiodine uptake and thyroid scintiscanning. *Endocrinol Metab Clin North Am.* 2001;30:291–313.

F. Oddie TH, Myhill J, Pirnique FG, et al. Effect of age and sex on the radioiodine uptake in euthyroid subjects. *J Clin Endocrinol Metab* 1968;28:776–782.

G. Rubow S, Klopper J, Wasserman H, et al. The excretion of radiopharmaceuticals in human breast milk: additional data and dosimetry. *Eur J Nucl Med* 1994;21:144–153.

H. Sarkar SD. Benign thyroid disease: What is the role of nuclear medicine? *Semin Nucl Med* 2006;36: 185–193.

I. Schneider PB. Simple, rapid thyroid function testing with 99mTc-pertechnetate thyroid uptake and neck/thigh ratio. *Am J Roentgenol* 1979;132:249–253.

J. Smith JJ, Croft BY, Brookeman VA, et al. Estimation of 24-h thyroid uptake of 131I sodium iodide using a 5-min uptake of technetium-99m pertechnetate. *Clin Nucl Med* 1990;15:80–83.

K. Vahjen GA, Lange RC, Merola TF. Thyroid uptake neck phantoms are not created equal [letter]. *J Nucl Med* 1992;33:304–305.