Measurement of Thyroid Iodine Uptake

JAF de Jong, Instituut Verbeeten, Tilburg
B de Keizer, University Medical Centre, Utrecht

Warning:
The intravenous administration of sodium perchlorate mentioned in this recommendation is a non-registered application.

1. Introduction
To determine the fraction of an arbitrary quantity of (radioactive) iodide taken up by the thyroid, using a small test dose.

2. Methodology
This guideline is based on available scientific literature on the subject, the previous guideline (Aanbevelingen Nucleaire Geneeskunde 2007), international guidelines from EANM and/or SNMMI if available and applicable to the Dutch situation.

3. Indication
a. As a parameter for the calculation of the therapeutic dose of ^{131}I NaI required in individualized dosing regimens.
b. In the framework of the differential diagnosis of congenital hypothyroidism (agenesis, prolapse disturbance, dyshormonogenesis). This application takes place only in conjunction with diagnostic imaging (thyroid gland scintigraphy with ^{123}I sodium iodide), and is described under the chapter 'Thyroid gland scintigraphy'.

Occasionally, as part of ^{123}I thyroid gland scintigraphy to aid in determining the cause of hyperthyroidism.

4. Contraindications
a. *Pregnancy:* Treatment with ^{131}I is absolutely contraindicated in pregnancy. Measurement of the ^{131}I uptake during pregnancy is futile, and is thus contraindicated.
b. *Lactation:* Breast feeding should be interrupted for at least 3 weeks according to ICRP 106.

5. Relation to other diagnostic procedures
The iodine uptake measurement is not an exact representation of the thyroid function under all conditions. For an accurate determination of the function, serum concentrations of TSH, fT4 (and possibly fT3) are indispensable. However, the uptake measurement is the only method available for describing the actual uptake of iodine by the thyroid.

6. Medical information necessary for planning
a. Indication: e.g. preparation for ^{131}I therapy.
b. Biochemistry results relating to the thyroid, such as TSH, fT4, fT3 and the possible presence of antibodies to thyroid (components).

c. Medication.
d. Pregnancy and lactation excluded?

7. Radiopharmaceutical

Preparation: ^{131}I-sodium iodide or ^{123}I-sodium iodide
Nuclide: iodine-131 or iodine-123
Activity ^{123}I: 2-4 MBq
Activity ^{131}I: 0,37 MBq
Administration: oral or intravenous (preferably the same rout as is used for therapy)

8. Radiation safety

As stated above, pregnancy and lactation are absolute contraindications for ^{131}I therapy. Also see: The SNMMI practice guideline for therapy of thyroid disease with ^{131}I 3.0 (JNM 2012).

Radiation Dosimetry for Adults

Radiopharma-ceutical	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*	3,7-11,1 p.o. (0,1-0,3)	3,2 Thyroid (12,0)	0,11 (0,41)
^{99}mTc-pertechnetate	74-370 i.v. (2-10)	0,062 ULI** (0,23)	0,013 (0,048)
Na^{131}I iodide*	0,15-0,37 p.o. (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

[SNMMI Procedure Guideline For Thyroid Uptake Measurement 3.0, September 2006]

Radiation Dosimetry for Children (5 year old)

Radiopharma-ceutical	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 p.o. (0,1-0,2)	16 Thyroid (59)	0,54 (2,0)
^{99m}Tc-pertechnetate	37-185 i.v. (2-10)	0,21 ULI** (0,78)	0,4 (0,15)
$Na^{131}I$ iodide* (usually not used in children)	0,15-0,37 p.o. (0,004-0,01)	1900 Thyroid (7000)	56 (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

[SNMMI Procedure Guideline For Thyroid Uptake Measurement 3.0, September 2006]

9. Patient preparation/essentials for procedure

a. The use of thyrostatics or combination therapy (thyrostatics plus levothyroxine) should be stopped 3 days prior to the investigation. Monotherapy with Propylthiouracil should be stopped for at least 15 days; monotherapy with levothyroxine should be stopped 4 weeks in advance. Alternatively, a suppressed TSH can be chosen as the standard condition.
b. Ensure the patient has not received large doses of iodine recently. For example in the form of x-ray/CT contrast media, iodinated drugs (amiodarone, cough syrups), cosmetics (povidone soap and shampoo), kelp tablets and other seaweed containing products (sushi). After such an iodine load, thyroid gland uptake of iodine, pertechnetate (and perchlorate) will be disturbed for 3 weeks to 6 months, depending on the amount of iodine received. Gadolineum contrast material (for MRI) does not block the iodine uptake by the thyroid gland.
c. A large meal can delay resorption of orally administered iodine, thereby leading to an underestimation of the iodine uptake. This must be avoided.

Essentials for procedure
Thyroid Probe or gamma camera.

a. The measurement is made at standard times after oral (or intravenous) administration of the radiopharmaceutical. As a rule the 24 h uptake rate is used to calculate the therapeutic dose of ^{131}I. It is advisable, however, to perform both an early measurement (4-6 h post administration) as well as a late measurement (24 h post administration) to allow assessment of the iodine metabolism in the thyroid ('iodine-turnover').
b. Positioning: The patient is placed in a comfortable upright position in front of the thyroid probe. The collimated probe is directed from a fixed distance (e.g. 10 cm) onto the thyroid bed (at the level of the cricoid cartilage).
c. Probe settings:
   Energy: ^{131}I-setting, 364 keV / for ^{123}I-159 keV.
   Window: 15-20%.
   Collimator: the collimator is a fixed component of the thyroid probe.
   Counting time: 2 min per measurement.
   Computer: for verification of the spectrum and the setting of the energy window.
d. The iodine uptake in the thyroid is measured for a duration of 2 min. To correct for background radiation (both within and outside the patient) a 2 min measurement of the femur can be taken (approximately 20 cm proximal to the knee).
e. For calibration of the patient measurements, a 2 min measurement is taken of an $^{131/123}$I source of known strength. In principle, the calibration source is of equal strength to the dose administered to the patient. The calibration source is placed in a phantom neck, and measured in the same geometry and with the same counting time as the patient's. Next, the background radiation in the examination room is measured for 2 min without calibration source.
f. The iodine uptake can now be calculated using the formula:

$$\text{Uptake (\%)} = (\text{Cneck} - \text{Cfem})/(\text{Ccal-Cbkg})$$

where Cneck is the number of counts measured at the neck, Cfem the number of counts measured at the femur, Ccal the number of counts measured at the calibration source, and Cbkg the number of counts (background radiation) measured in the examination room.

10. Interpretation

a. Normal values: up to 15% for the 5 h uptake measurement, up to 25% for the 24 h uptake measurement. In patients with a toxic multinodular goitre the iodine absorption is not always increased.
b. If values are lower than expected, a further history should be taken with regards to possible recent iodine use e.g. in food, contrast agent or medication.
c. The iodine uptake is measured in order to accurately calculate the indicated ^{131}I therapeutic dose. Care should be taken to ensure equal circumstances at the time of measurement and therapy. Even under standardised conditions the uptake percentage of ^{131}I is subject to relatively strong fluctuations, especially in patients with Graves' disease. It is therefore advisable that the iodine uptake be measured as closely as

possible to the ^{131}I therapy, and certainly, no more than one week in advance.

d. The level of background radiation should not depend on the positioning of the thyroid probe. When measuring the background radiation (over the femur), the probe is directed at the floor. When measuring the neck, the probe is directed at the wall. Of course, storage of radiopharmaceuticals or scintigraphic investigations should not occur directly behind this wall.
e. A normal thyroid gland is butterfly-shaped, and located just above the suprasternal notch. A thyroid of normal size will lie entirely within the probe's measurement field. An enlarged goitre, however, may lie partly outside the measuring field of the collimated probe. In which case the iodine uptake percentage will be underestimated leading to overdoses of ^{131}I-therapy.
f. Different suppliers use different quantities of cold iodine in their preparations. The uptake will therefore vary depending on the preparation. It is advisable to use the same preparation for both the uptake measurements and the therapy.
g. A constant high voltage on the thyroid probe is essential for accurate measurement results. Calibration is also a prerequisite, since the response to different doses of ^{131}I is not linear. Quality controls for these and other parameters are described in the 'Recommendations relating to the scintillation counter (thyroid probe)'.

11. Report

The percentages of early (4-6 h) and/or late (24 h) iodine uptake are mentioned. Indicate whether or not these percentages are within the normal range and whether or not they match the clinical and biochemical findings.

12. Literature

- ACR–SNM–SPR Practice Guideline For The Performance Of Thyroid Scintigraphy And Uptake Measurements. October 1, 2009.
- Helena R. Balon, Edward B. Silberstein, Donald A Meier et al. Society of Nuclear Medicine Procedure Guideline for Thyroid Scintigraphy, version 3.0, approved September 10, 2006.
- Helena R. Balon, Edward B. Silberstein, Donald A Meier et al. Society of Nuclear Medicine Procedure Guideline for Thyroid Uptake Measurement, version 3.0, approved September 5, 2006.
- Cavalieri R. In vivo isotopic tests and imaging: quantitative in vivo isotopic tests. In: SH Ingbar and LE Braverman (editors), The thyroid; a fundamental and clinical text. 6th Edition, Philadelphia: JB Lippincott Co., 1991:437-45.
- M. Dietlein, J. Dressler, W. Eschner et al. Verfahrensanweisung zum Radioiodtest (Version 3). Nuklearmedizin, juni 2007.
- Van Isselt JW, De Klerk JMH, Koppeschaar HPF, Van Rijk PP. Iodine-131 uptake and turnover rate vary over short intervals in Graves' disease. Nucl Med Comm 2000;21:609-16.
- Lee KH, Siegel ME, Fernandez OA. Discrepancies in thyroid uptake values. Use of commercial thyroid probe systems versus scintillation cameras. Clin Nucl Med 1996;21:268-9.
- Shackett P. Drugs and studies affecting I-123 uptake: suggested withholding times. In: P Shackett. Nuclear medicine technology; procedure guidelines and quick reference. Philadelphia: Lippincott Williams & Wilkins, 2nd edition 2009:435.
- Visser TJ, De Jong M. Productie en metabolisme van schildklierhormonen. In: WM Wiersinga en EP Krenning (editors), Schildklierziekten, 2e druk. Houten/Diegem: Bohn Stafleu Van Loghum, 1998:1-18.
- ICRP Publication 53, Radiation Dose to Patients from Radiopharmaceuticals, 1994 edition.
- Nederlandse Internisten Vereniging, Richtlijn Schildklierfunctiestoornissen Revisie 2012. www.internisten.nl.