Purpose and Background Information

Under the supervision of a technologist, perform a complete radioiodine uptake procedure on a patient. This test assesses thyroid function. Thyroid uptake is the fraction of an administered amount of radioactive iodine that accumulates in the thyroid at selected times following ingestion. This test requires multiple measurements conducted over two days. We will measure the uptake at intervals of about 24 hours or less post administration.

Radioactive iodine is administered in the form of a capsule or liquid. (Typically a capsule is administered because the radiation safety requirements on capsules are easier to execute and less prone to failure. For example, liquids can splash but capsules do not.) Patient uptake measurements are made after 4 to 6 hours and again after 24 hours with the aid of a non-imaging scintillation counter, called a scintillation probe or a thyroid probe (Fig. 1), to detect the presence of radioactive iodine. Radioactive iodine uptake (RAIU) studies and thyroid scans are often performed together. However, they are usually acquired with different instrumentation and provide different and complementary information.

Imaging scans are acquired with a gamma camera that is typically fitted with a pinhole collimator that looks like a funnel (Fig. 2) While a gamma camera can be used to quantitatively assess thyroid uptake, the more accurate and reliable method uses a scintillation probe which is specialized for this task. The thyroid probe typically has a 5-cm thick × 5-cm diameter sodium iodine crystal with an open,
cylindrically shaped, single-hole lead collimator coupled to a single photomultiplier tube and electronics (Fig 3).

![Figure 3: Drawing of probe components.](image)

The lead collimator is placed in front of the NaI crystal for the purpose of defining an area from which the radiations will be detected (dashed arrows). When a patient’s thyroid is placed in front of this collimated area at a fixed distance from the detector, a reproducible geometry for consistent measurements is created. This is essential to accurately measure changes in activity in the thyroid. The thyroid must be placed in a very reproducible geometry for every measurement to avoid errors that can result from inverse-square-law effects or errors introduced because the thyroid is not completely in the field of view.

The probe is capable of measuring an energy spectrum and uses pulse height analysis with an energy window like the gamma camera but with no positioning signal produced because this instrument is a counting device only. Therefore, the window set will be dependent on the radionuclide used for uptake.

Pharmaceuticals used for Thyroid Uptake Studies

Sodium iodide-123 (I-123) and sodium iodide-131 (I-131) are the two radio-pharmaceuticals used clinically. I-131 undergoes beta-minus decay and emits a gamma photon of 364 keV (81% abundance) with an 8-day physical half-life. The I-131 high-energy beta emissions and long physical half-life result in a high radiation dose to the patient, particularly to the thyroid, for small administered activities. The absorbed dose to the thyroid is about 10 mGy/μCi administered.
This fact severely limits the amount of activity that can be administered for any diagnostic test. Typically, only 30 μCi of I-131 is administered, resulting in a thyroid dose of 300 mGy for patients with normal thyroids (about 25% uptake).

I-123 decays by electron capture with a half-life of 13.2 hours. The principal gamma emission is a 159-keV photon (83.4% abundance), which is more efficiently detected by scintillation detectors than is the 364 keV photon from I-131. And I-123 emits no beta particle. The absorbed dose to the thyroid from an administration of I-123 is about 0.5 mGy/μCi. These facts render I-123 more favorable for uptake and imaging studies. For a typical administration of 200 μCi the absorbed dose to a normal thyroid is about 100 mGy, or about three times less for more favorable measurements and higher quality imaging than with I-131.

**Preparation Prior to Thyroid Uptake Studies**

Before administering the capsule to the patient and preferably before ordering the capsule for the uptake measurement, determine if the patient has had any radionuclide tests, other tests or is taking any medications or consuming any foods that will interfere with the uptake procedure. Suppression of uptake by exogenous iodine may preclude accurate uptake measurements. As little as 1 mg of stable iodine can cause a marked reduction in uptake. Ten milligram can effectively block the gland (98% reduction). Radiographic contrast media is a common source of iodine that interferes with radioiodine thyroid studies. A food, drug, and imaging history should be obtained from patients before thyroid uptake and imaging studies to assure no recent intake of stable iodine. Refer to the hospital policy that lists drugs, foods and other factors that may interfere with the test.

**Methodology for Thyroid Uptake Data Collection**

*Perform these steps with the technologist and fill in the blanks when completed*

1) **Preliminary measurements**
   i) Which Radionuclide was used today? ___I-123 or ___I-131

<table>
<thead>
<tr>
<th>Why are there different calibration selection buttons on the dose calibrator for tablet or liquid form of I-123 and not for I-131?</th>
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<tbody>
<tr>
<td>Since tablet form of I-123 is the most commonly administered dose, we will assume for the remainder of this exercise that that is what is used. Measured activity is___________microcurie.</td>
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ii) **Assay** the Iodine dose in the dose calibrator using the appropriate calibration selection, i.e., I-131 or I-123 and tablet or liquid form (wear gloves and your radiation monitor).

iii) **Compare** your dose calibrator result to the supplier’s assay and check to see if they are within 20% of physician approved dosage as required by regulation.

Your calibrated reading is: __________ microcurie versus supplier’s calibrated dose __________ microcurie.

Physician prescribed dosage: __________ microcurie. Are they within 20%? __________. Did you take into account the different times of the calibrations and the time when the dose is to be administered to the patient? Why might the time make a difference?

iv) **Measure room background.** Room background must be determined using the uptake probe and the neck phantom with no radioactive materials in the area or in the phantom. Count empty neck phantom (room background) using appropriate window for 1 minute. Be sure front of phantom is centered in the FOV and at the standard distance (typically 25 cm from the face of the sodium iodide detector that is recessed in the collimator).

Measured number of counts is __________ counts/minute

![Figure 3: A neck phantom.](image)

v) **Make a measurement** of the activity with the dose inside the thyroid receptacle of the neck phantom. Counts are obtained with the detector placed at the standardized distance. Wear gloves and transfer dose to neck phantom without touching capsule (slide capsule from one container to the other). Set up under standard geometry and count for 1 minute.

Measured counts are: __________ counts/minute. This is the number of counts you would get if the patient had 100% uptake of iodine.
vi) **Remove activity** from the area and store the dose in safe place in radiopharmacy.

b) **Patient’s first measurements before administering dose:**
   i) Count patient’s neck and lower thigh (patient background) for 1 minute. Use same setup as with the neck phantom.

   | Counts in patient’s neck | counts/minute. |
   | Counts over patient’s thigh | counts/minute. |
   | Are they significantly different? | |
   | Should they be significantly different? | |
   | Why do this for both the neck and thigh? | |

   **Administer dose orally.**

c) **How to administer dose.**
   i) Wear gloves, lab coat and your personal radiation monitor.
   ii) Place capsule in small disposable paper cup without touching the capsule.
   iii) Give that cup and drinking water in a disposable container to the patient.
   iv) Have the patient transfer the capsule from the cup to their mouth and swallow it with plenty of water.
   v) Discard disposable cups as radioactive trash.

2) **Uptake measurements**

For patient measurements after the dose has been administered, careful attention to setting up the patient for counting is more critical than before. At appropriate time intervals, the probe is placed at the standard distance from the anterior surface of the patient’s neck and **centered on the thyroid cartilage** (Fig 4), so that the entire gland can be detected by the probe but most extrathyroidal activity is not. Because all the tissue in the neck is not thyroid, the patient’s lower thigh is counted to assess **patient background** (circulatory iodine in the blood, for instance) in manner similar to the thyroid measurement. This thigh count will be used as a correction to the thyroid measurement. Note: Facility may use a prescribed counting time that is different from our 1 minute count. But one minute is typically adequate.

a) **Uptake measurement at 4-6 hours (REQUIRED)**
   i) Count patient’s neck for 1 minute. Count rate is ____counts/minute.
   ii) Count lower thigh for 1 minute. Count rate is ____counts/minute.
b) Uptake measurement at 24 hours (REQUIRED)
   i) Count patient’s neck for 1 minute. Count rate is _______ counts/minute.
   ii) Count lower thigh for 1 minute. Count rate is __________ counts/minute

3) Calculation of uptake

The percent radioiodine uptake (RAIU%) at the different time intervals is calculated according to this formula:

\[
\text{RAIU\%} = \frac{\text{Neck Counts} - \text{Thigh Counts}}{(\text{Phantom Counts} - \text{Background Counts}) \times \text{Decay Correction Factor}} \times 100
\]

What is the decay correction factor and why is it necessary? ________________________________

Decay is automatically corrected by the computer program which stores information on the radionuclide’s half-life and the calendar date and time. If the radionuclide, the calendar date or the time is not set properly in the computer, the wrong % uptake will be calculated.

Possible sources of error

1. Variations in detector distance: Using the same geometry in counting both the patient and the phantom is essential to ensure the identical detector to source conditions and controlling the number of gamma rays reaching the crystal.

2. No neck phantom use: The phantom is used to simulate the patient’s neck for absorption of radiation and production of scattered radiation.

3. Improper centering of the probe over the patient’s neck: Mispositioning of the probe can cause the collimator to partially exclude some of the gamma rays emitted from the thyroid gland. This will artificially reduce the calculated uptake value.

4. Electronic instability: Reliable performance of the uptake probe system is essential for accurate results. Daily calibration should include counting a long-lived reference source to check for system constancy performance.
5. Recent administration of other radionuclide: Radionuclides present in patients from prior nuclear medicine exams or treatments can produce false uptakes if not identified by questioning patient prior to dose administration.

6. Interfering food/medications: Many medications contain iodine and those radiographic procedures that using contrast expands the inorganic iodine pool, with resultant low uptakes. Medications that block the physiologic use of iodine also interfere with the uptake assessment.

7. Contamination of the neck phantom: Radioactivity can be transferred to the phantom. If not subtracted from the dose counts will falsely decrease the calculated uptake.

9. Radioactivity in an adjacent area: Changes in room background can affect both phantom and patient counts and thus the calculated uptake. The sources of changing in background counts can be adjacent areas with radioactive patients or unshielded radioactive sources.

10. Wrong radionuclide entered into computer: This will result in incorrect decay correction.

11. Date or time not set properly in computer: This will also result in incorrect decay correction.
Questions

Why is the uptake dose activity used for I-131 30 microcuries and I-123 over 200 microcuries?

What is the purpose of using the plastic phantom?

Why is it important to maintain a consistent distance from the neck and phantom?

From a staff safety perspective, why would you prefer capsule over liquid?

When is a written directive required?

After you answer the questions turn in a copy of this report for credit to the Physics and Education Offices.

Resident Name (print): ________________________________________________

Completed lab on: ____/___/_______

Signature of individual supervising lab: _________________________________