Thyroid scans

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This article forms part of our 'Tests and results' series for 2012, which aims to provide information about common tests that general practitioners order regularly. It considers areas such as indications, what to tell the patient, what the test can and cannot tell you and interpretation of results.

Keywords
thyroid gland/radionuclide imaging; nuclear medicine; hyperthyroidism; thyroid nodule

Thyroid scans are functional tests that assess the activity of the thyroid. This is in contrast to ultrasound, which provides information on gross morphology or biopsy that provides histological information. Early thyroid scans were done with radioactive iodine. This has largely been replaced by technetium (Tc-99m) pertechnetate, which sufficiently mimics the behaviour of iodine, involves a much lower radiation dose and costs considerably less. Iodine scans are now only used for specific situations in cases of proven thyroid cancer.

Guidelines provided by the Society of Nuclear Medicine[1] and the American College of Radiology[2] are exhaustive with regard to indications and medicines/substances to avoid with thyroid scans. This article attempts to highlight the key information mentioned in those documents in a manner relevant to current general practice.

How does the test work?

Tc-99m pertechnetate is injected intravenously into the arm and images of the thyroid are obtained with a scintillation camera approximately 20 minutes later. The radionuclide emits gamma rays (photons) at a predictable rate. The camera is set to detect a predetermined minimum number of photons. Images are usually obtained from anterior, left anterior oblique and right anterior oblique projections. These phases typically last for several minutes each, with a total scanning time of about 10–20 minutes.

The bilobed thyroid gland has reasonably homogenous distribution of activity in both lobes. There is usually slight asymmetry of the lobes (the right being slightly larger), with the lobes joined inferiorly and medially by the isthmus. Two anterior images are usually taken in a study. The first is taken with a sternal notch marker (at a greater stand-off) to check for substernal extension of the thyroid. The appearance of a normal thyroid scan is shown in *Figure 1*.

What is the radiation dose?

Radiation dose is measured in units of millisieverts (mSv). For typical activities of thyroid scans administered to adults, the effective radiation dose (ie. the dose to the whole body) is approximately 3.2 mSv. *Table 1* compares this to the background radiation

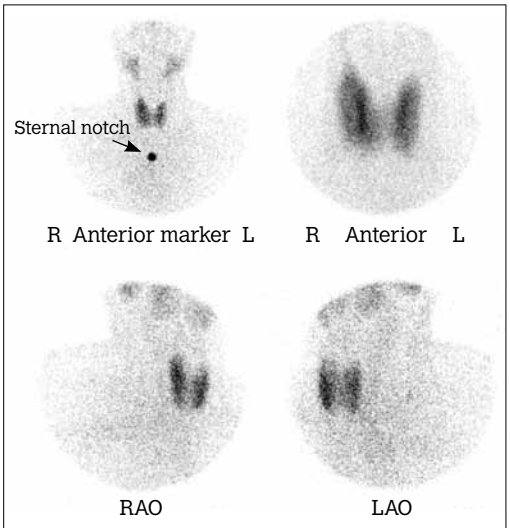

Figure 1. Normal thyroid scan, displayed in standard projections
RAO = right anterior oblique
LAO = left anterior oblique

level in Australia and to the effective dose from some other commonly performed diagnostic imaging tests.

What are the indications?

In addition to a relevant history, examination and thyroid function testing (TFT), thyroid scans can assist in the work-up of patients with thyroid conditions.[3] Typical scan appearances are shown in *Figure 2*. In practice, the two main applications of thyroid scans are to:

- differentiate the causes of hyperthyroidism
- assess thyroid nodules when the patient has hyperthyroidism.

In general, thyroid nodules less than 10 mm in diameter are usually too small to be accurately assessed with a thyroid scan.

Table 1. Radiation dose for thyroid scans and other diagnostic imaging tests

Test/situation	Total effective dose (mSv)
Chest X-ray[6]	0.1
Annual Australian background[7]	1.5–2.0
Thyroid scan[1]	3.2
Bone scan[4]	6.0
CT abdomen + pelvis[6]	15.0

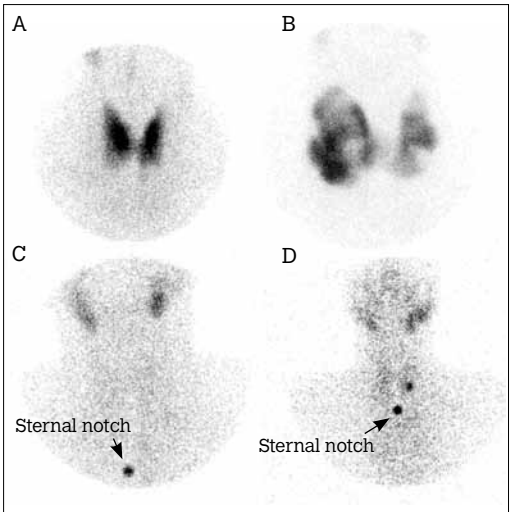

Figure 2. Typical scan appearances of common causes of thyrotoxicosis A) Graves disease; B) Multinodular goitre; C) Thyroiditis; D) Autonomous nodule

Do they show up thyroid cancer?

No. Although primary or secondary carcinomas of the thyroid almost invariably appear as nonfunctioning ('cold') areas on the radionuclide images,[4] most (>90%) 'cold' lesions are due to benign processes (eg. thyroiditis, cyst, adenoma). Nevertheless, if a 'cold nodule' is found on thyroid scan, further investigation, such as ultrasound and/or fine needle biopsy, is recommended.[1]

How does it fit in with ultrasound and other tests for assessment of nodules?

If the patient is hyperthyroid, a thyroid scan is helpful in elucidating the function of a nodule. But if the patient is euthyroid (or hypothyroid), then a thyroid ultrasound is the preferred first line investigation.[3]

Are there any contraindications?

Apart from pregnancy, there are no absolute contraindications to thyroid scanning. Pertechnetate is excreted in breast milk, so breastfeeding women are advised to express and discard breast milk for 26 hours after injection.[5] Also, uptake of the radiotracer will be inhibited (and thus nondiagnostic scans may arise) if the patient is taking or exposed to iodine supplementation or thyroxine therapy. These are discussed in more detail in the section on patient information.

What information should be provided on the request form?

Table 2 outlines the information that should be provided on the thyroid scan request for the nuclear medicine physician to optimally interpret the scan findings.

What information does the patient need?

The patient should understand the rationale for the investigation and be aware of the radiation exposure involved. They should expect the process to take 45–60 minutes. They will be able to remain dressed, but they will need to have an intravenous injection via the arm and they may need to remove neck jewellery.

After the scan they will be able to drive and resume a normal diet and activities. Women of childbearing age should be asked about any potential pregnancy or if they are breastfeeding. There is a Medicare rebate available, but patients should enquire about any out-of-pocket costs.

The referring doctor should be aware of the medicines and substances that may affect the thyroid scan results. The most commonly encountered are water soluble intravenous contrast agents (of the type used for computed tomography [CT] scans) and amiodarone.[2] A more complete list is shown in *Table 3*. For patients taking thyroxine or liothyronine (Tertroxin), the referring doctor should discuss patient preparation with the nuclear medicine physician before proceeding with a thyroid scan.

What do the results mean?

If the indication has been to differentiate between the causes of hyperthyroidism, then the pattern of uptake will provide an indication of the diagnosis (eg. Graves disease, multinodular goitre, thryoiditis), which enables an understanding of the natural history and can guide treatment.

If the indication for the test was assessment of a thyroid nodule when the patient has hyperthyroidism, and the nodule is functioning (or 'hot') then treatment of the hyperthyroidism is the most likely next step. If the nodule is not functioning (or 'cold') then further investigation, such as ultrasound and/or fine needle biopsy is recommended.[1]

Case study

A previously well woman, 54 years of age, presented to an emergency department with palpitations. She also reported tremor and heat intolerance. However, she had no local symptoms in the neck. Clinically, the patient had an irregular heart rate of 120 bpm with a right-sided dominant thyroid nodule without lymphadenopathy. Pemberton sign was negative. There was no evidence of orbitopathy.

Thyroid function tests showed a high free thyroxine level (52 pmol/L; reference range 7.0–17) and a suppressed thyroid stimulating hormone (TSH) level (<0.05 mIU/L). Electrocardiogram showed

Table 2. Information to include on the request form
Pertinent clinical history
Findings on physical examination of the neck
Pregnancy/breastfeeding status
History of potentially interfering medications (eg. thyroid hormones, iodine containing medicines)
Exposure to iodinated contrast
Ingestion of iodine rich foods (eg. kelp)
Pertinent laboratory data (especially TFT results)
Results of prior thyroid imaging tests (ultrasound, CT, MRI) if available

Table 3. The time that patients should optimally wait after iodine supplementation is discontinued to minimise the risk of a nondiagnostic thyroid scan	
Saturated solution of potassium iodide, Lugol solution	4 weeks
Some mineral/vitamin supplements (check ingredients information)	4 weeks
Amiodarone	6 months
Water soluble (intravenous) contrast	4 weeks

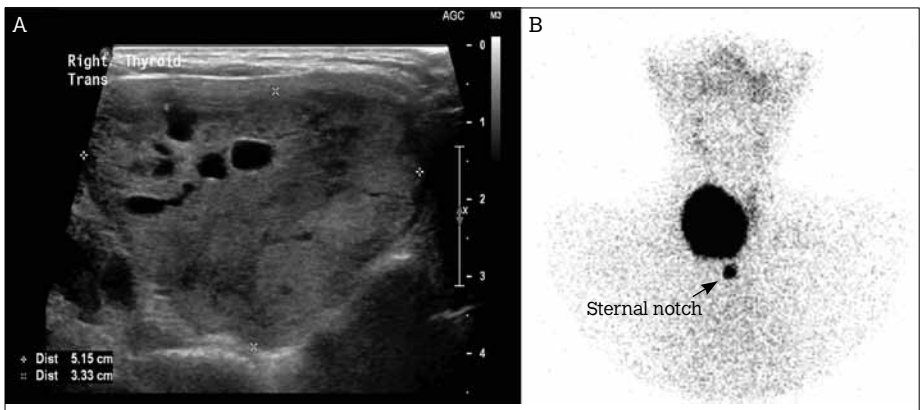

Figure 3. Autonomous right lobe nodule. A large nodule (measuring over 5 cm in maximum dimension) was identified on ultrasound (A). The thyroid scan (B) showed it to be hyperfunctioning

atrial fibrillation with a rapid ventricular response. Ultrasound showed a large solid nodule in the right lobe of the thyroid (*Figure 3a*). The thyroid scan showed intense trapping of pertechnetate by the nodule. Since normal pertechnetate uptake is dependent on TSH, there was no uptake in the remainder of the thyroid due to TSH suppression (*Figure 3b*). She was initially treated with carbimazole (20 mg twice daily).

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