Procedure Guideline for Parathyroid Scintigraphy

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Key Words: parathyroid scintigraphy; procedure guideline; hyperparathyroidism; parathyroid neoplasms

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PART I: PURPOSE

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

PART II: BACKGROUND INFORMATION AND DEFINITIONS

Primary hyperparathyroidism is characterized by increased synthesis and release of parathyroid hormone, which produces an elevated serum calcium level and a decline in serum inorganic phosphates. Asymptomatic patients frequently are diagnosed through screening by automatic multichemistry panels. The vast majority of cases of primary hyperparathyroidism (80%–85%) are due to single or multiple hyperfunctioning adenomas. Hyperplasia of several or all parathyroid glands accounts for approximately 12%–15% of cases, while parathyroid carcinomas occur in only 1%–3% of cases of hyperparathyroidism. In general, parathyroid adenomas larger than 500 mg can be detected scintigraphically. Recently, ^{99m}Tc-sestamibi has allowed detection of hyperplastic glands, although with less sensitivity than adenomas.

Dual-phase or double-phase imaging refers to using ^{99m}Tc-sestamibi and acquiring early and delayed images. Dual-isotope or subtraction studies refers to protocols using two different radiopharmaceuticals for image acquisition.

PART III: COMMON INDICATIONS

A. To localize hyperfunctioning parathyroid tissue (adenomas or hyperplasia) in primary hyperparathyroidism. This may be useful prior to surgery to help the surgeon find the lesion, thus shortening procedure time.

   Although use of preoperative localizing procedures, including parathyroid scintigraphy, is controversial, selected high-surgical-risk patients and those with life-threatening adenomas are likely to benefit from parathyroid scintigraphy. An unequivocally positive study will aid the surgeon in streamlining the surgical procedure.

B. To localize hyperfunctioning parathyroid tissue (usually adenomas) in patients with persistent or recurrent disease. Many of these patients will already have had one or more surgical procedures, making re-exploration much more technically difficult. Also, ectopic tissue is much more prevalent in this population, and preoperative localization will likely increase surgical success.

PART IV: PROCEDURE

A. Patient Preparation

   No special patient preparation is necessary.

   The procedure should be explained to the patient, as preventing patient motion during the study is extremely important, particularly if using dual-imaging/subtraction techniques. Patients who are unable or unwilling to remain completely immobilized during the study may require sedation.

B. Information Pertinent to Performing the Procedure

   1. Documentation of elevated serum calcium and parathyroid hormone.
   2. Results of physical examination, especially palpation of the neck.
   3. Presence of concurrent thyroid disease, especially nodular thyroid disease.
   4. Recent administration of iodine-containing preparations, such as for radiographic studies (i.e., CT scans, intravenous urography), or thyroid hormone, when the technique using thyroid imaging and subsequent subtraction will be employed.
   5. Results of CT or ultrasound scans and other diagnostic tests.

C. Precautions

   None

D. Radiopharmaceuticals (See Table 1.)

   1. Thallium-201-chloride (^{201}Tl)

      Thallium-201 has a physical half-life of 72 hr. Its main photopeak is due to characteristic x-rays of mercury, which have an energy range of 69–83 keV. There are also gamma rays produced at 167 keV (8% abundance) and 135 keV (2% abundance). The administered radioactivity is 75–130 MBq (2–3.5 mCi) and is given intravenously. Thallium-201 is taken up by both abnormal parathyroid tissue and thyroid tissue in proportion to blood flow.

   2. Technetium-99m-pertechnetate (^{99m}Tc)

      Technetium-99m has a half-life of 6 hr and an energy of 140 keV. Pertechnetate is used for delineating the thyroid gland, since pertechnetate is trapped by functioning thyroid tissue. This image is subtracted from the ^{201}Tl or ^{99m}Tc-sestamibi image, and what remains is potentially a parathyroid adenoma. When using ^{201}Tl, the administered radioactivity of ^{99m}Tc-pertechnetate is generally 75–150 MBq (2–4 mCi), depending on the administered radioactivity of ^{201}Tl and which of the two radiopharmaceuticals is administered first. When using ^{99m}Tc-sestamibi, the admin-

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TABLE 1
Radiation Dosimetry for Adults

Radiopharmaceutical	Administered activity MBq (mCi)	Organ receiving the largest radiation dose*† mGy (rad)	Effective dose*† mSv (rem)
^{201}Tl-chloride	75–130 i.v.	0.54 Kidney	0.23
	(2.0–3.5)	(2.0)	(0.85)
^{99m}Tc-pertechnetate (no blocking agent)	75–150 i.v.	0.062 ULI	0.013
	(2–4)	(0.23)	(0.048)
^{99m}Tc-sestamibi	185–925 i.v.	0.039 Gallbladder	0.0085
	(5–25)	(0.14)	(0.03)
^{123}I (15% uptake)	7.5–20 p.o.	1.9 Thyroid	0.075
	(0.2–0.5)	(7)	(0.278)

*ICRP 53, pages 199, 264, 373; ICRP 62, page 23.
†Per MBq (per mCi).
ULI = upper large intestine.

istered radioactivity of pertechnetate is generally 185–370 MBq (5–10 mCi), since sestamibi has a higher total activity in the thyroid gland than ^{201}Tl.

3. Technetium-99m-sestamibi (^{99m}Tc-sestamibi)
The range of intravenously administered radioactivity is 185–925 MBq (5–25 mCi); the typical dosage is 740 MBq (20 mCi). This radiopharmaceutical localizes in both parathyroid tissue and functioning thyroid tissue, but it usually washes out of normal thyroid tissue more rapidly than out of abnormal parathyroid tissue. (Hyperplastic parathyroid glands generally show faster washout than most adenomas.)
4. Iodine-123 sodium iodide (^{123}I)
Iodine-123 has a half-life of 13 hr and emits a photon with an energy of 159 keV. It has been used as a thyroid imaging agent in subtraction studies, particularly with ^{99m}Tc-sestamibi. Its administered radioactivity, when given orally, is 7.5–20 MBq (200–550 μCi).

E. Image Acquisition
Digital data should be acquired in a 128 × 128 or larger matrix.

1. Planar images of the neck and mediastinum can be obtained with a gamma camera fitted with a high-resolution collimator. Images of the mediastinum should be obtained in all cases. Although the yield is low, the positive predictive value is quite high. Mediastinal images are most helpful in cases of residual or recurrent disease, where there is a much higher likelihood of ectopic tissue. Additional pinhole or converging collimator images of the neck may be useful. When using ^{201}Tl, there is not uniform agreement over which agent to administer first, since there are advantages and disadvantages for each protocol. If ^{201}Tl is given first, there is the advantage of administering the lower energy radionuclide first and avoiding problems with technetium scatter. There also is the advantage of being able to image the mediastinum. However, the disadvantage is the requirement that the patient hold still for a longer time. The advantage of administering the ^{99m}Tc-pertechnetate first is less time that the patient must remain motionless. However, there is the disadvantage of downscatter of ^{99m}Tc into the thallium window, as well as not being able to image the mediastinum. These studies should be acquired and stored digitally so that image manipulation can be performed. Acquiring a dual-isotope image may avoid registration problems.
2. Technetium-99m-sestamibi studies may be performed using either dual-phase and/or subtraction techniques. If the subtraction technique is used, the procedure is similar to thallium subtraction imaging. Either pertechnetate or ^{123}I can be given first, followed by ^{99m}Tc-sestamibi, or sestamibi can be given first followed by pertechnetate. (^{123}I cannot be administered following sestamibi because of the long time needed for localization.) Overall, none of the above techniques have been shown to be superior. However, careful selection of technique on a case-by-case basis may be helpful. Disadvantages of ^{123}I include its high cost and the long time required for localization. Using pertechnetate or ^{123}I as the first imaging agent, high-count (10-min) images are obtained 30 min or 4 hr after radiopharmaceutical administration, respectively. Sestamibi is then injected, and high-count (10-min) images are obtained 10 min postinjection. If pertechnetate is injected after sestamibi images are obtained, the patient should be immobilized for 15–30 min after the pertechnetate injection, and then a 10-min image acquired. In all cases, both sets of images are normalized to total thyroid counts and computer subtraction of ^{123}I or pertechnetate images from the sestamibi images is obtained.
If a dual-phase study is performed, then a high-resolution parallel-hole collimator or a pinhole or converging collimator can be used. Early (10 min postinjection) and delayed (1 1/2 to 2 1/2 hr postinjection) high-count images are obtained.
Early and late SPECT imaging may also be useful, as SPECT imaging has shown promising results in detecting recurrent hyperparathyroidism with ectopic adenomas. Cine of volume-rendered images may be helpful.
With large-field-of-view gamma cameras, magnification may be of help.

F. Interventions
None

G. Processing
Processing with computer subtraction is necessary only with dual-radiopharmaceutical studies.

1. In ^{201}Tl/^{99m}Tc-pertechnetate studies, computer subtraction may enhance detection of parathyroid adenomas. The two images should be normalized; that is, counts per pixel in the thyroid in one image should equal that in the other image. The pertechnetate image is then subtracted from the thallium image. However, normalization by this method can be difficult due to heterogeneity. An alternative method is to decrease the counts severalfold by dividing the ^{201}Tl image by a constant and then using successive subtractions until the body of the thyroid disappears. Image shifting can be used to ensure optimal registration of the two images.
2. In ^{99m}Tc-sestamibi/^{123}I or pertechnetate imaging studies, the images should be normalized similar to

the technique for $^{201}Tl/^{99m}Tc$, and the ^{123}I or pertechnetate image then subtracted from the ^{99m}Tc-sestamibi image.

H. Interpretation/Reporting

Thallium-201/^{99m}Tc images and $^{99m}Tc/^{123}I$ images should be inspected visually as well as evaluated with computer subtraction and/or with rapid alternating display of images (cine). Abnormal parathyroid tissue will appear as an area of relatively increased uptake with either ^{201}Tl or ^{99m}Tc-sestamibi. Computer subtraction will probably be of help in cases with equivocal visual findings. If ^{99m}Tc-sestamibi is used without ^{123}I or pertechnetate (i.e., without computer subtraction), the two sets of images (early and delayed) are inspected visually. Abnormal parathyroid tissue usually will appear as an area of increased uptake and should become more prominent on the delayed images. However, some adenomas will show washout of tracer by 2–2 1/2 hr. Many hyperplastic glands will show rapid washout.

I. Quality Control

Gamma camera quality control will vary from camera to camera. Multiple spatial and energy window registration should be checked periodically if dual-isotope studies are performed. For further guidance in gamma camera quality control, refer to the *Society of Nuclear Medicine Procedure Guideline for General Imaging* for routine quality control procedures for gamma cameras.

J. Sources of Error

1. Patient motion.
2. Image misregistration.
3. Adenomas or hyperplastic glands less than 500 mg in size are often difficult to detect.
4. Ectopic adenomas can be difficult to detect; the entire neck as well as the upper and mid mediastinum to the heart should be imaged.
5. Lesions of the thyroid, such as adenomas and carcinomas, may be indistinguishable from parathyroid adenomas.
6. Parathyroid carcinomas are also indistinguishable from parathyroid adenomas.
7. Recently administered radiographic contrast material or thyroid hormone (within the previous 3–4 weeks) will interfere with ^{123}I and pertechnetate imaging and will therefore compromise the use of subtraction techniques. This will not be a problem with dual-phase sestamibi studies.

PART V: DISCLAIMER

The Society of Nuclear Medicine has written and approved guidelines to promote the cost-effective use of high-quality nuclear medicine procedures. These generic recommendations cannot be applied to all patients in all practice settings. The guidelines should not be deemed inclusive of all proper procedures or exclusive of other procedures reasonably directed to obtaining the same results. The spectrum of patients seen in a specialized practice setting may be quite different than the spectrum of patients seen in a more general practice setting. The appropriateness of a procedure will depend in part on the prevalence of disease in the patient population. In addition, the resources available to care for patients may vary greatly from one medical facility to another. For these reasons, guidelines cannot be rigidly applied.

Advances in medicine occur at a rapid rate. The date of a guideline should always be considered in determining its current applicability.

PART VI: ISSUES REQUIRING FURTHER CLARIFICATION

There does appear to be a consensus developing in the literature that ^{99m}Tc-sestamibi imaging is more sensitive than ^{201}Tl imaging. There is not yet a consensus regarding dual-phase versus subtraction techniques.

PART VII: CONCISE BIBLIOGRAPHY

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PART VIII: LAST HOUSE OF DELEGATES APPROVAL DATE

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PART IX: NEXT ANTICIPATED APPROVAL DATE

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Procedure Guideline for Hepatic and Splenic Imaging

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Key Words: hepatic imaging; splenic imaging; procedure guideline

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PART I: PURPOSE

The purpose of this guideline is to assist nuclear medicine practitioners in recommending, performing, interpreting and reporting hepatic and splenic imaging studies.

PART II: BACKGROUND INFORMATION AND DEFINITIONS

A. Liver-spleen imaging is performed following the injection of a ^{99m}Tc-labeled colloid that has been rapidly phagocytized by the reticuloendothelial cells of the liver, spleen and bone marrow.

B. Liver blood pool imaging is performed following the injection of ^{99m}Tc-labeled red blood cells for the detection of cavernous hemangiomas of the liver.

C. Hepatic perfusion studies are performed following the injection of ^{99m}Tc-macroaggregated albumin (MAA) through a hepatic artery catheter to determine that intra-arterially administered chemotherapeutic agents are optimally delivered.

D. Splenic imaging is performed following the injection of ^{99m}Tc-labeled heat-damaged red blood cells. Damaged red blood cells are selectively taken up by functioning splenic tissue.

PART III: COMMON INDICATIONS

A. Liver-Spleen Imaging

This study can be used to determine the size and shape of the liver and spleen as well as detect functional abnormalities of the reticuloendothelial cells of these organs. Specifically, these studies are occasionally performed for the following reasons:

1. Suspected focal nodular hyperplasia of the liver.

   These lesions often have normal or increased uptake on sulfur colloid (SC) imaging.

2. To assess the function of the reticuloendothelial system in patients with suspected liver disease.

   The decision to perform a liver biopsy or to continue treatment with a hepatotoxic agent may be influenced by the severity of liver disease that is seen on liver-spleen imaging.

B. Liver Blood Pool Imaging

This study is highly specific for cavernous hemangiomas of the liver. The sensitivity for detecting large lesions of the liver (>2 cm–3 cm) is also high. Hemangiomas as small as 0.5 cm may be detected with SPECT.

C. Hepatic Perfusion Imaging

This study is useful for demonstrating that hepatic artery catheters used to infuse chemotherapeutic agents are optimally positioned to perfuse liver tumors and to avoid perfusion of normal extrahepatic tissues (e.g., stomach).

D. Splenic Imaging

This study is used to detect functional splenic tissue. This study is often performed:

1. In children to rule out congenital asplenia or polysplenia.
2. In adults whose thrombocytopenia has been previously treated with splenectomy.
3. To characterize an incidentally noted mass as functional splenic tissue.

PART IV: PROCEDURE

A. Patient Preparation

No patient preparation is required.

B. Information Pertinent to Performing the Procedure

1. Relevant history and results of physical examination.
2. Results of other anatomic imaging studies.
3. Results of liver function tests.
4. For splenic imaging, results of a complete blood and platelet count.
5. For hepatic perfusion studies, position of the hepatic artery catheter.

C. Precautions

When red blood cells are labeled, strict adherence to a

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