THE SNM PRACTICE GUIDELINE FOR PARATHYROID SCINTIGRAPHY 4.0

PREAMBLE

These guidelines are an educational tool designed to assist practitioners in providing appropriate care for patients. They are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care. For these reasons and those set forth below, the Society of Nuclear Medicine (SNM) cautions against the use of these guidelines in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the physician or medical physicist in light of all the circumstances presented. Thus, an approach that differs from the guidelines, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in the guidelines when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations of available resources, or advances in knowledge or technology subsequent to publication of the guidelines.

The practice of medicine involves not only the science, but also the art of dealing with the prevention, diagnosis, alleviation, and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. Therefore, it should be recognized that adherence to these guidelines will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe
medical care. The sole purpose of these guidelines is to assist practitioners in achieving this objective.

I. INTRODUCTION

The purpose of this document is to provide nuclear medicine practitioners with general guidelines on parathyroid scintigraphy, including, but not limited to, radiopharmaceuticals used to perform the study and generally accepted examination techniques.

II. GOAL

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

III. 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 are frequently identified by routine laboratory screening. The vast majority of cases of primary hyperparathyroidism (80–90%) are due to single hyperfunctioning adenomas. Multigland hyperplasia and double adenomas account for approximately 10% 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. Hyperplastic glands, can be detected but with less sensitivity than adenomas.

Dual phase or double phase imaging refers to acquisition of early and delayed images with $^{99m}$Tc sestamibi. Dual isotope or subtraction imaging refers to protocols using two different radiopharmaceuticals.

IV. EXAMPLES OF CLINICAL AND RESEARCH INDICATIONS

Indications for parathyroid scintigraphy include, but are not limited to the following:

A. While no published appropriateness criteria exist for parathyroid scintigraphy, parathyroid scintigraphy is specifically designed to localize parathyroid adenoma(s) or parathyroid hyperplasia in patients with hyperparathyroidism that is determined based on elevated parathyroid hormone (PTH) levels in the setting of an elevated serum calcium level. (1-8).

B. Localization of hyperfunctioning parathyroid tissue (adenomas or hyperplasia) in primary hyperparathyroidism. This is useful prior to surgery to help the surgeon localize the lesion, thus shortening the time of the procedure. In the past when surgery involved bilateral neck exploration, parathyroid scintigraphy was controversial. (1-5, 9-12). However, with present day minimally invasive
parathyroidectomy, pre-operative parathyroid scintigraphy may be extremely
useful in reducing the duration or extent of surgical exploration.

C. Localization of hyperfunctioning parathyroid tissue in patients with persistent or
recurrent disease. Many of these patients will already have had one or more
surgical procedures, making re-exploration more technically difficult. Also,
ectopic tissue is more prevalent in this population, and pre-operative localization
will likely increase surgical success, in part by helping to direct the surgical
approach (6, 13-16).

D. Localization of hyperfunctioning parathyroid tissue for intraoperative localization
using a probe or a small camera. This can be helpful, particularly in patients with
persistent or recurrent disease, especially in those who have undergone previous
surgical exploration.

V. QUALIFICATIONS AND RESPONSIBILITY OF PERSONNEL

Please see SNM Procedure Guideline for General Imaging

VI. PROCEDURE/SPECIFICATIONS OF THE EXAMINATION

A. Information Pertinent to Performing the Procedure

1. Documentation of an elevated serum calcium and parathyroid hormone.
   Documented increased urinary excretion of calcium is also advised when the
   other laboratory abnormalities are mild.

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 i.v. contrast
   or thyroid hormone, when the technique of thyroid imaging and subsequent
   subtraction will be employed.

5. Results of CT, MR or Ultrasound.

B. Patient Preparation and Precautions

1. No special patient preparation is necessary.

   The procedure should be explained to the patient, such as preventing patient
   motion during the study is extremely important, particularly if using dual
   isotope/subtraction techniques. Patients who are unable or unwilling to remain
   completely immobilized during the study may require sedation.
2. No relevant precautions.

C. Radiopharmaceuticals

1. Tc-99m sestamibi

The range of intravenously administered radioactivity in adults is 370-925 MBq (10-25 mCi); the typical dosage is 740-925 MBq (20-25 mCi). This radiopharmaceutical localizes in both parathyroid tissue and thyroid tissue, but usually washes out from normal and possibly abnormal thyroid tissue more rapidly than from abnormal parathyroid tissue. (Hyperplastic parathyroid glands generally show faster washout than most adenomas and can be more difficult to detect.)

3. Tc-99m pertechnetate

$^{99m}$Tc has a physical half-life of 6 h and 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 $^{99m}$Tc-sestamibi image, and what remains is potentially a parathyroid adenoma. The administered activity of pertechnetate is generally 74-370 MBq (2-10 mCi).

4. Iodine-123 Sodium Iodide ($^{123}$I-iodide)

$^{123}$I has a half-life of 13 hr, and emits a photon with energy of 159 keV. It has been used as a thyroid imaging agent in subtraction studies, with $^{99m}$Tc-sestamibi. The administered radioactivity, given orally, ranges from 7.5–22 MBq (200–600 µCi).

D. Protocol/Image Acquisition

1. Image Acquisition

a. Digital data should be acquired in a 128 x 128 or larger matrix.

b. Field of view

Planar images of the neck and mediastinum can be obtained with a gamma camera fitted with a high-resolution collimator. Images including the mediastinum should be obtained in all cases. Although the yield is lower than with SPECT, the positive predictive value is quite high. Mediastinal images are particularly helpful in cases of residual or recurrent disease, where there is a much higher likelihood of ectopic parathyroid tissue. Additional pinhole or converging collimator images of the neck may be useful. If SPECT is not available, anterior oblique images may be useful. With large field of view gamma cameras, magnification may be of help.
c. Dual phase $^{99m}$Tc-sestamibi protocol
   If a dual phase study is performed, then a high-resolution parallel hole
collimator or a pinhole or converging collimator can be used. Early (10-15
min postinjection) and delayed (1½–2½ hr post injection) high-count
images are obtained of the neck and chest.

   Dual phase imaging is not useful with Tetrofosmin because of rapid
washout from parathyroid tissue.

d. SPECT
   SPECT and SPECT/CT have proven useful and provide more precise
anatomical localization. (18, 19, 21) This is particularly true for localizing
ectopic lesions. In the mediastinum, accurate localization may assist in
directing the surgical approach, such as median sternotomy versus left or
right thoracotomy. Cine of volume-rendered images may be helpful. Cine
Maximum Intensity Projection (MIP) may be very helpful in reviewing
images with referring physicians as it allows one to quickly estimate the
anterior/posterior orientation of the lesions. Whether SPECT improves
sensitivity is debatable; published results have been variable (17). The
combination of anatomical and functional imaging, i.e. SPECT/CT,
provides the most optimal localization for surgical planning and additional
diagnostic information (18, 19).

2. Protocols for SPECT/CT
   a. Specific Procedure for SPECT/CT dual-phase $^{99m}$Tc-sestamibi
      scintigraphy:
   The optimal approach is to acquire studies on an integrated SPECT/CT
device, but software fusion (co-registration) of images obtained on
separate SPECT and CT devices can be used when an integrated device is
not available. The general technical guidance for SPECT/CT is outlined
in the respective SNM procedure guideline (1). One must exercise extreme
cautions when fusing separately acquired SPECT and CT studies when
dealing with co-registration of such tiny structures. Subtle changes in neck
positioning may make fusion totally misleading.

   The adult patient receives 555-925 MBq (15-25 mCi) of $^{99m}$Tc-sestamibi
by intravenous injection. If planar images are acquired, they should be
obtained first (see section IV.C.1 for further details). These images
provide information that can supplement /CT data, especially if the latter
is compromised by a technical difficulty (such as patient motion,
equipment failure, etc.). Anterior planar images of the neck (magnified as
appropriate to visualize parotid glands (or angle of the jaw) cranially and
extending to fully include the thyroid caudally, as well as the neck and
chest view (no magnification, including parotid glands cranially and the
inferior myocardium caudally) are obtained 15 min after injection (early)
and repeated 120 min later (delayed), each typically for 10 min on 256 x 256 (16 bit) matrix, using a large-field-of-view gamma camera fitted with a high-resolution low-energy parallel-hole collimator. SPECT/CT can be obtained immediately following the planar images, at the early, the delayed, or both time points. While two SPECT acquisitions can be performed without exposing the patient to any additional radiation, the CT component exposes patients to radiation each time it is performed. Therefore, it should be considered carefully whether it should be employed at both or only one time point. There is suggestion one large published study that has found early SPECT/CT in combination with delayed planar, SPECT, or SPECT/CT to have highest accuracy (21). Early SPECT or SPECT/CT has highest accuracy because of the many patients without rapid washout.

When possible, the SPECT data should be acquired over a 360° arc, using a body contoured elliptical orbit, optimally obtaining 120 (minimum of 60) projections at 15-25 sec per projection (every 3° to 6° angles), depending on the number of projections and sensitivity of the detector. The SPECT acquisition takes on average approximately 25 min. The images are acquired into a 128 x 128 (16 bit matrix, corrected for attenuation, and reconstructed using a 2-dimensional ordered-subset expectation maximization iterative technique (at least 10 subsets and 2 iterations are typical, but may vary according to a manufacturer). A 3-dimensional postfilter, which should be specified in detail by the manufacturer (for example, the Hanning postfilter with a cutoff frequency of 0.85 cycles/cm) is typically applied to the SPECT data-set.

The CT component of the examination is performed for lesion localization and attenuation correction. The optimal slice thickness, acquisition time and CT parameters (mAs and kVp) should be determined by individual laboratories or suggested by the manufacturer to maximize image quality and to minimize radiation exposure to the patient. The highest possible spatial resolution should be sought in setting up the imaging protocol. While the typical parameters are a tube current ranging from 100-200 mAs and a voltage of 120 kVp (ranging from 100-140 kVp), these may vary by manufacturer and in some systems may be automatically modulated, depending on the body part imaged. Intravenous contrast enhancement is not usually performed, but may be useful or justifiable in selected cases.

Optimal display of the acquired image-sets includes SPECT, CT, and fusion images reconstructed in three standard projections (axial, coronal, and sagittal). It is preferable for all three sets to be co-registered so that the same body region is displayed on any one of the numbered slices of any given projection. This allows for the most reliable comparison between the image-sets for anatomical and functional correlation.
b. Dual isotope $^{99m}$Tc-sestamibi/$^{99m}$Tc-pertechnetate protocol

$^{99m}$Tc-pertechnetate can be administered first, followed by $^{99m}$Tc-sestamibi, or $^{99m}$Tc-sestamibi can be administered first followed by $^{99m}$Tc-pertechnetate. When $^{99m}$Tc-pertechnetate is injected first, high count (10 min) images are obtained 30 min after radiopharmaceutical administration. $^{99m}$Tc-sestamibi is then injected and high count (10 min) images are obtained 10 min later. If $^{99m}$Tc-pertechnetate is injected after $^{99m}$Tc-sestamibi images are obtained, the patient should be immobilized for 15–30 min after the $^{99m}$Tc-pertechnetate injection, and then a 10 min image is acquired. In all cases, frame normalization can be performed, and computer subtraction of $^{99m}$Tc-pertechnetate images from the $^{99m}$Tc-sestamibi images is performed (3, 8, 10, 12, 17, 22, 24).

c. Dual isotope $^{99m}$Tc-sestamibi/$^{123}$I-iodide protocol

$^{123}$I-iodide must be given first, followed by $^{99m}$Tc-sestamibi. $^{123}$I-iodide cannot be administered following sestamibi, due to its much lower administered activity, as well as the long time needed for localization and imaging. High count (10 min) images are obtained 4 h after $^{123}$I administration. $^{99m}$Tc-sestamibi is then injected and high count (10 min) images are obtained 10 min postinjection. Both sets of images are normalized to total thyroid counts and computer subtraction of $^{123}$I-iodide images from the $^{99m}$Tc-sestamibi images is generated. Disadvantages of $^{123}$I include cost and long time required for localization.

None of the preceding techniques has been shown to be diagnostically superior; however, careful selection of technique on a case-by-case basis may be helpful.

2. Processing

In $^{99m}$Tc-sestamibi or $^{123}$I-iodide/$^{99m}$Tc-pertechnetate imaging studies, the images should be normalized and the $^{123}$I-iodide or $^{99m}$Tc-pertechnetate image is subtracted from the $^{99m}$Tc-sestamibi image.

E. Interpretation

1. Dual phase $^{99m}$Tc-sestamibi or tetrofosmin

If $^{99m}$Tc-sestamibi is used without $^{123}$I-iodide or $^{99m}$Tc-pertechnetate (dual phase), the two sets of images (early and delayed) are inspected visually. Abnormal parathyroid tissue usually appears as an area of increased uptake, and becomes more prominent on the delayed images. However, some lesions (10–15%) will show washout of tracer by 2–21/2 h. Many hyperplastic glands show rapid washout. Washout of tracer from adenomas is variable. SPECT
images may reveal lesions not seen on planar images, and SPECT/CT images may provide better localization of abnormal findings on functional imaging.

2. Dual isotope protocols

$^{99m}$Tc-sestamibi/$^{99m}$Tc-pertechnetate and $^{99m}$Tc-sestamibi/$^{123}$I-iodide images should be inspected visually as well as evaluated with computer subtraction and/or with rapid alternating display of images (cine). Abnormal parathyroid tissue appears as an area of relatively increased $^{99m}$Tc-sestamibi uptake. Computer subtraction may be useful in cases with equivocal visual findings.

3. Interpretation of the images should include complete description of the planar, SPECT, CT and fusion image-sets. The primary goal is to render the opinion on the presence of abnormal parathyroid tissue, such as single or multiple parathyroid lesions. Those findings require detailed description of the anatomical location of the lesion including relationship to the neighboring structures (for example, the thyroid gland, trachea, esophagus, vessels, etc). Incidental pathology in the imaged field also should be described (9, 12, 13, 20-23).

F. Interventions

None

VII. DOCUMENTATION/REPORTING

In addition to patient demographics, the report should include the following information:

A. Indication for the study

B. Procedure

1. Radiopharmaceutical(s)

   a. Dosage and route of administration

   b. If more than one radiopharmaceutical is used, the order and the timing of administration should be stated.

2. Acquisition and Display

   a. Timing of acquisition of images

   b. Planar and/or SPECT
For planar images, list projections acquired (e.g. anterior) and region imaged (neck, mediastinum). For SPECT, list timing of acquisition post-injection and region imaged (neck or mediastinum).

C. Findings

1. Time of detection of lesion (early or late images)

2. Location (thyroid bed—upper or lower pole or ectopic, and which side, or mediastinum); a more precise localization may be possible with SPECT and SPECT/CT

D. Study limitations, confounding factors (e.g. patient motion), previous thyroidectomy

E. Interpretation

VIII. EQUIPMENT SPECIFICATION

Any properly functioning gamma camera may be used to acquire the images in parathyroid scintigraphy. Parallel-hole collimation is the standard for imaging the neck and mediastinum, though pinhole collimation can be used for better evaluation of the neck.

Computer acquisition is necessary for the dual-radiopharmaceutical technique with subtraction. It is often helpful for qualitative visual analysis in single radiopharmaceutical studies as well.

IX. QUALITY CONTROL AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION CONCERNS

See also the SNM Procedure Guideline for General Imaging

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.

A. Sources of Error

1. Patient motion.

2. Image misregistration.
3. Adenomas or hyperplastic glands less than 600 mg in size are more difficult to detect (17).

4. Ectopic adenomas can be difficult to detect; the entire neck as well as the upper mediastinum to the level of the heart should be imaged.

5. Thyroid lesions, such as adenomas and carcinomas, may be indistinguishable from parathyroid lesions.

6. Parathyroid carcinomas are indistinguishable from other parathyroid lesions.

7. Recently administered radiographic contrast material or thyroid hormone (within the previous 3–4 wk) may interfere with $^{123}$I and pertechnetate imaging, and will therefore compromise the use of subtraction techniques. This is not a problem with dual phase sestamibi studies.

8. Previous thyroidectomy can be a problem, especially for precise lesion localization, mainly with the subtraction technique.

B. Issues Requiring Further Clarification

There is now a clear consensus that imaging with $^{99m}$Tc-sestamibi is superior to $^{201}$Tl-chloride, $^{201}$Tl-chlorideshould no longer be used. A few investigators have utilized $^{99m}$Tc-tetrofosmin; however, it is not clear if this agent is comparable to $^{99m}$Tc-sestamibi. There is still no consensus regarding subtraction imaging versus dual phase imaging. There is a developing consensus that SPECT and SPECT/CT are most useful, for improving precision of anatomical localization (17,18,19,21).

There is still controversy regarding the utility of this study as a pre-operative evaluation in primary hyperparathyroidism in patients who have not had prior surgery. However, there are now some data that these studies may shorten the operative time and reduce cost. In cases of residual or recurrent disease, these studies are clearly helpful.

There are some data emerging that $^{18}$F-Fluorodeoxyglucose (FDG) Positron Emission Tomography (PET) imaging may be useful in imaging parathyroid adenomas. PET studies are probably most useful in difficult cases where $^{99m}$Tc-sestamibi or tetrofosmin have failed to localize the cause for a high PTH level. PET imaging would generally involve the use of F-18 FDG, or possibly C-11 methionine outside the U.S.

X. RADIATION SAFETY IN IMAGING

See also Section X. of the SNM Guideline for General Imaging
It is the position of SNM that patient exposure to ionizing radiation should be at the minimum level consistent with obtaining a diagnostic examination. Reduction in patient radiation exposure may be accomplished by administering less radiopharmaceutical when the technique or equipment used for imaging can support such an action. Each patient procedure is unique and the methodology to achieve minimum exposure while maintaining diagnostic accuracy needs to be viewed in this light. Radiopharmaceutical dose ranges outlined in this document should be considered as a guide. Dose reduction techniques should be utilized when appropriate. The same principles should be applied when CT is used in a hybrid imaging procedure. CT acquisition protocols should be optimized to provide the information needed while minimizing patient radiation exposure. Parathyroid imaging is not usually indicated in children.

### Radiation Dosimetry for Adults

<table>
<thead>
<tr>
<th>Radio-pharmaceuticals</th>
<th>Administered Activity MBq (mCi)</th>
<th>Organ Receiving the Largest Radiation Dose</th>
<th>Organ Receiving the Largest Radiation Dose</th>
<th>Effective Dose</th>
<th>Effective Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>mGy/MBq (rad/mCi)</td>
<td>mGy (rad)</td>
<td>mSv/MBq (rem/mCi)</td>
<td>mSv (rem)</td>
</tr>
<tr>
<td>$^{203}$Tl- chloride$^1$</td>
<td>75 – 130 i.v. (2.0 – 3.5)</td>
<td>0.48 Kidney (1.8)</td>
<td>36 - 62</td>
<td>0.14 (0.52)</td>
<td>10-18 (1.0-1.8)</td>
</tr>
<tr>
<td>$^{99m}$Tc-pertechnetate$^2$ No blocking agent</td>
<td>75 – 150 i.v. (2 – 4)</td>
<td>0.057 Upper Large Intestine (0.21)</td>
<td>4.3 - 8.6 (0.43 - 0.86)</td>
<td>0.013 (0.048)</td>
<td>0.98 - 2.0 (0.098 - 0.2)</td>
</tr>
<tr>
<td>$^{99m}$Tc-sestamibi (rest)$^2$</td>
<td>185 – 925 i.v. (5 – 25)</td>
<td>0.039 Gallbladder (0.14)</td>
<td>7.2 - 36 (0.72-3.6)</td>
<td>0.009 (0.033)</td>
<td>1.6 - 8.3 (0.16 - 0.83)</td>
</tr>
<tr>
<td>$^{99m}$Tc-tetrofosmin (rest)$^3$</td>
<td>185 – 925 i.v. (5 – 25)</td>
<td>0.027 Gallbladder (0.10)</td>
<td>5.0 - 25 (0.5 - 2.5)</td>
<td>0.0069 (0.026)</td>
<td>1.3 - 6.4 (0.13 - 0.64)</td>
</tr>
<tr>
<td>$^{123}$I-iodide (35% Uptake)$^4$</td>
<td>7.5 – 20 p.o. (0.2 – 0.6)</td>
<td>4.5 Thyroid (17)</td>
<td>34 - 90 (3.4 - 9.0)</td>
<td>0.22 (0.81)</td>
<td>1.6 - 4.4 (0.16 - 0.44)</td>
</tr>
</tbody>
</table>

1. ICRP Publication 106, 2008 (25)
2. ICRP Publication 80, 1998 (26)
3. ICRP Publication 53, 1987 (27) and ICRP Publication 80, 1998 (26)

### Radiation Dosimetry in Fetus/Embryo: $^{99m}$Tc Sestamibi

Dose estimates to the fetus were provided by Russell et al. (28) No information about possible placental crossover of this compound was available for use in estimating fetal doses.

$^{99m}$Tc Sestamibi-rest
Radiation Dosimetry in Fetus/Embryo: $^{99m}$Tc-tetrofosmin

Dose estimates to the fetus were provided by Russell et al. (28). No information about possible placental crossover of this compound was available for use in estimating fetal doses. Separate estimates were not given for rest and exercise subjects.

<table>
<thead>
<tr>
<th>Stage of Gestation</th>
<th>Fetal Dose</th>
<th>mGy/MBq (rad/mCi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td>0.015</td>
<td>(0.055)</td>
</tr>
<tr>
<td>3 months</td>
<td>0.012</td>
<td>(0.044)</td>
</tr>
<tr>
<td>6 months</td>
<td>0.0084</td>
<td>(0.031)</td>
</tr>
<tr>
<td>9 months</td>
<td>0.0054</td>
<td>(0.020)</td>
</tr>
</tbody>
</table>

Radiation Dosimetry in Fetus/Embryo: $^{99m}$Tc-pertechnetate

Dose estimates to the fetus were provided by Russell et al. (28). Information about possible placental crossover of this compound was available and was used in estimating fetal doses.

<table>
<thead>
<tr>
<th>Stage of Gestation</th>
<th>Fetal Dose</th>
<th>mGy/MBq (rad/mCi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td>0.0096</td>
<td>(0.036)</td>
</tr>
<tr>
<td>3 months</td>
<td>0.0070</td>
<td>(0.026)</td>
</tr>
<tr>
<td>6 months</td>
<td>0.0054</td>
<td>(0.020)</td>
</tr>
<tr>
<td>9 months</td>
<td>0.0036</td>
<td>(0.013)</td>
</tr>
</tbody>
</table>
Radiation Dosimetry in Fetus/Embryo: $^{123}$I-NaI

Dose estimates to the fetus were provided by Russell et al. (28). Information about possible placental crossover of this compound was available and was used in estimating fetal doses.

<table>
<thead>
<tr>
<th>Stage of Gestation</th>
<th>Fetal Dose (mgGy/MBq) (rad/mCi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td>0.020 (0.074)</td>
</tr>
<tr>
<td>3 months</td>
<td>0.014 (0.052)</td>
</tr>
<tr>
<td>6 months</td>
<td>0.011 (0.041)</td>
</tr>
<tr>
<td>9 months</td>
<td>0.0098 (0.036)</td>
</tr>
</tbody>
</table>

Also of high importance in cases involving radioiodine administrations to the pregnant patient is the possible dose to the fetal thyroid, which takes up iodine after 10-13 weeks' gestation (29):

<table>
<thead>
<tr>
<th>Gestational age (months)</th>
<th>Fetal thyroid dose (per unit activity administered to the mother) (mgGy/MBq) (rad/mCi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2.7 (10)</td>
</tr>
<tr>
<td>4</td>
<td>2.6 (9.6)</td>
</tr>
<tr>
<td>5</td>
<td>6.4 (24)</td>
</tr>
<tr>
<td>6</td>
<td>6.4 (24)</td>
</tr>
<tr>
<td>7</td>
<td>4.1 (15)</td>
</tr>
<tr>
<td>8</td>
<td>4.0 (15)</td>
</tr>
<tr>
<td>9</td>
<td>2.9 (11)</td>
</tr>
</tbody>
</table>

Radiation Dosimetry in Fetus/Embryo: $^{201}$Tl-chloride

Dose estimates to the fetus were provided by Russell et al. (28). No information about possible placental crossover of this compound was available for use in estimating fetal doses.
# The Breast Feeding Patient

The ICRP 106 (International Commission on Radiation Protection) (30), suggests a 48-hour interruption of breast feeding for subjects receiving $^{201}\text{Tl}$-chloride and the authors recommend that no interruption is needed for breastfeeding patients administered $^{99m}\text{Tc}$-Technetium-sestamibi or tetrofosmin, but a 12 hrs interruption time for $^{99m}\text{Tc}$-pertechnetate and a greater than 3 weeks interruption for $^{123}\text{I}$-NaI.

### XI. ACKNOWLEDGEMENTS

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XII. APPENDIX

North Shore Long Island Jewish Health System (NSLIJH) Parathyroid Subtraction Technique

A $^{99m}$Tc-sestamibi/$^{99m}$Tc-pertechnetate dual-tracer protocol is used. An IV line is placed in the patient’s forearm prior to beginning the procedure. Approximately 10 minutes following injection of 30-35 mCi $^{99m}$Tc-sestamibi, patients undergo early imaging of the neck using a pinhole collimator. Data are acquired dynamically at 2 minutes/frame for five frames (10 minutes total) as 128x128 matrices.

Immediately following Early $^{99m}$Tc-sestamibi imaging, SPECT (SPECT/CT) is performed.

After completing SPECT (SPECT/CT), about 90 min post injection, pinhole imaging of the neck is repeated. Data are acquired as 128x128 matrices at 2 minutes/frame for 25 frames (50 minutes). For the first 10 frames data are acquired using only residual MIBI activity (Late MIBI image). During the 11th - 12th frames, 7 mCi of $^{99m}$Tc-pertechnetate is injected intravenously, (through the previously established intravenous line) and imaging (Thyroid) continues for the remainder of the test.

Cinematic playbacks of unprocessed Early and Late data are reviewed to identify and exclude frames demonstrating patient motion or other artifacts likely to affect subsequent image processing and interpretation. After frame deletion, the remaining frames are summed to create composite Early and Late $^{99m}$Tc-sestamibi images, and the composite Thyroid image. The composite Early and Late $^{99m}$Tc-sestamibi images are normalized to the composite Thyroid image and all 3 composite images then are background subtracted. Finally the composite Thyroid image is digitally subtracted from the composite Late $^{99m}$Tc-sestamibi image to produce the Subtraction image.

The technique of course is not useful in patients who previously underwent total thyroidectomy. False negative subtraction images are encountered in patients with decreased thyroid uptake of $^{99m}$Tc-pertechnetate due to hormone replacement, thyroiditis, etc. A pre scanning questionnaire decreases the likelihood of this happening. Another potential problem is $^{99m}$Tc infiltration, so at the end of the study an image of the injection site is obtained routinely.

XII. BIBLIOGRAPHY/REFERENCES


**XII. BOARD OF DIRECTORS APPROVAL DATES:**

Version 1.0 January 14, 1996

Version 2.0 February 7, 1999

Version 3.0 June 2, 2004