Procedure Guideline for Bone Scintigraphy: 1.0

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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 bone scintigraphy.

PART II: BACKGROUND INFORMATION AND DEFINITIONS

A. Bone scintigraphy is a diagnostic imaging study which records the distribution of a radioactive tracer in the skeletal system in planar (2-dimensional) and/or tomographic (three-dimensional) images.
B. Whole-body bone scintigraphy produces planar images of the skeleton including anterior and posterior views of the axial skeleton. Anterior and/or posterior views of the appendicular skeleton are also obtained. Additional views are obtained as needed.
C. Limited bone scintigraphy records images of only a portion of the skeleton.
D. Bone SPECT (single-photon emission computed tomography) produces a tomographic image of a portion of the skeleton.
E. Multiphase bone scintigraphy usually consists of blood flow images, immediate images and delayed images. The blood flow images consist of a dynamic sequence of planar images of the area of greatest interest obtained as the tracer is injected. The immediate (blood-pool) images consist of one or more static planar images of the areas of interest, obtained within 10 min after injection of the tracer. Delayed images may be limited to the areas of interest or may include the whole body, may be planar or tomographic, and are usually acquired 2 to 5 hr after injection. Further additional delayed images obtained up to 24 hr following tracer injection may be obtained if necessary.

PART III: COMMON INDICATIONS

Because metabolic changes usually precede anatomic changes, bone scintigraphy can often detect abnormalities before anatomic imaging studies such as routine radiographs. In addition, because the radiopharmaceutical is distributed throughout the body, examination of the entire skeleton is facilitated.

Bone scintigraphy may be indicated in a diverse patient population (children, adults, symptomatic and asymptomatic). Before bone scintigraphy, several factors deserve consideration: (a) the likelihood of the suspected condition in view of the clinical presentation, (b) whether bone scintigraphy is the best modality at this point in the diagnostic work-up and (c) the effect of bone scintigraphy will have on patient management. Bone scintigraphy is often helpful in the management of patients with neoplastic disease. In these patients, tumor histology and clinical stage should be considered to determine the likelihood of metastasis to the skeleton.

The following is a partial list of common clinical settings for which bone scintigraphy is indicated. This list is not all-inclusive. The following indications are not listed in a specific order and bone scintigraphy is not necessarily the primary diagnostic imaging study.

A. Neoplastic disease
B. Occult fracture
C. Osteomyelitis
D. Avascular necrosis
E. Arthritides
F. Reflex sympathetic dystrophy
G. Bone infarcts
H. Bone graft viability
I. Otherwise unexplained bone pain
J. Distribution of osteoblastic activity prior to ^{89}Sr therapy

PART IV: PROCEDURE

A. Patient Preparation

The rationale for performing the procedure and the details of the procedure itself should be explained to the patient in advance. Unless contraindicated, patients should be well hydrated and instructed to drink two or more 8-oz glasses of water between the time of injection and the time of delayed imaging. The patient should be asked to urinate immediately prior to delayed imaging and to drink plenty of fluids for at least 24 hr after radiopharmaceutical administration.

B. Information Pertinent to Performing the Procedure

1. Question(s) to be answered by bone scintigraphy.
2. History of fractures, trauma, osteomyelitis, cellulitis, edema, arthritis, neoplasms, metabolic bone disease or limitation of function.
3. Current symptoms, physical findings.
4. History of recent scintigraphy, especially with ^{131}I, ^{67}Ga and ^{111}In.
5. Results of prior bone scintigraphy.
6. Results of prior imaging studies such as conventional radiographs, CT and MRI.
7. History of therapy that might affect the results of bone scintigraphy (e.g., antibiotics, steroids, chemotherapy, radiation therapy, diphosphonates, iron therapy).
8. History of orthopedic (e.g., presence and location of prosthetic implants) and nonorthopedic surgery (e.g., ileal conduit) that might affect the results of bone scintigraphy.
9. Relevant laboratory results (e.g., PSA in patients with prostate cancer).
10. History of anatomic or functional renal abnormalities.

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C. Precautions
1. Elective bone scintigraphy should be deferred in pregnant women. Bone scintigraphy is not contraindicated in pregnancy when the expected benefits of the examination outweigh the very small radiation risk.
2. When possible, breastfeeding should be discontinued for 24 hr after radiopharmaceutical injection.

D. Radiopharmaceutical

Several ^{99m}Tc-labeled radiopharmaceuticals (e.g., diphosphonates or pyrophosphates) are available for bone scintigraphy. The usual administered activity for adult patients is 740 to 1110 MBq (20 to 30 mCi) injected intravenously. For markedly obese adult patients, the administered activity may be increased to 11–13 MBq/kg (300–350 μCi/kg). For pediatric patients, the administered activity is 9–11 MBq/kg (250–300 μCi/kg), with a minimum of 40–90 MBq (1.0–2.5 mCi). The maximum administered activity for pediatric patients should not exceed the administered activity for an adult.

Bone radiopharmaceuticals are subject to oxidation. Care should be taken to avoid introducing air into the multidose vial. Quality control should be performed prior to administration of the radiopharmaceutical (see the Society of Nuclear Medicine Procedure Guideline for Imaging with Radiopharmaceuticals, *J Nucl Med* 1996: in press).

Radiation Dosimetry for Adults*

Radiopharmaceuticals	Administered activity MBq (mCi)	Organ receiving the largest radiation dose† mGy (rad)	Effective dose† mSv (rem)
^{99m}Tc phosphates and phosphonates	740–1110 i.v. (20–30)	0.063 Bone (0.23)	0.008 (0.030)

*ICRP 53, normal bone uptake, normal renal function, page 215.
†per MBq (per mCi)
See also MIRD Committee Dose Estimate Report No. 13. Radiation absorbed dose for technetium-99m-labeled bone imaging agents. *J Nucl Med* 1989;30:1117–1122.

Radiation Dosimetry for Children* (5 year old)

Radiopharmaceuticals	Administered activity MBq/kg (mCi/kg)	Organ receiving the largest radiation dose† mGy (rad)	Effective dose† mSv (rem)
^{99m}Tc phosphates and phosphonates	9–11 i.v. (0.25–0.30)	0.22 Bone (0.81)	0.025 (0.093)

*ICRP 53, normal bone uptake, normal renal function, page 215.
†per MBq (per mCi)
See also MIRD Committee Dose Estimate Report No. 13. Radiation absorbed dose for technetium-99m-labeled bone imaging agents. *J Nucl Med* 1989;30:1117–1122.

E. Image Acquisition

If flow images are done, the camera should be positioned over the region of interest prior to injecting the tracer. The acquisition computer should be programmed to acquire approximately 30 frames for approximately 1–2 sec per frame. If film is used, 3–5 sec per frame may be used. The acquisition should be started just as the tracer is injected. Blood-pool images should be acquired within 10 min of tracer injection for approximately 3–5 min per image. After 10 min, some activity may be apparent in the skeleton.

When digital images are acquired, blood flow images may be obtained in 64 × 64 × 16 or greater matrix at 1 to 3 sec per frame. Blood-pool images are usually obtained in 128 × 128 × 16 or greater matrix with count density of approximately 300,000 counts/image (150,000–200,000 counts/image may be adequate for extremities).

Routine delayed images are usually obtained from 2 to 5 hr after injection. Additional delayed (6–24 hr) images will result in a higher target-to-background ratio and may permit better evaluation of the pelvis if it was obscured by bladder activity on the routine delayed images. Six- to 24-hr delayed imaging may be particularly helpful in patients with renal insufficiency and patients with urinary retention.

Whole-body bone scintigraphy can be accomplished with multiple overlapping images (i.e., spot imaging) or with continuous images (i.e., whole-body scan) obtained in anterior and posterior views. When spot views are used as the primary method of acquiring bone images, the areas of bony skeleton covered by the spot views must overlap to avoid missing regions of the skeleton.

The first spot view of the axial skeleton, usually the chest, is acquired for approximately 500,000 to 1 million counts. The remaining spot views are then acquired for the same time as the first view. Spot images may be obtained using a 128 × 128 × 16 or a 256 × 256 × 16 matrix. Whole-body views are usually obtained in 256 × 1024 × 16 or greater matrix.

Computer acquisition, processing and display of images may be particularly helpful in pediatric populations because of extreme ranges of normal uptake. Films of scintigrams photographed with different intensities may also be helpful if digital processing and review are not available.

When whole-body scanning is used, the count rate (usually of the anterior chest) should be determined before image acquisition. The scanning speed should be adjusted so that routine (obtained 2–5 hr after injection) delayed anterior or posterior whole-body images contain >1.5 million counts. If the scanner electronically joins multiple passes, care must be taken to avoid having the "zipper" superimposed on the spine.

When the probability of disseminated disease is small, a limited study is reasonable. When disseminated disease is more likely, spot views limited to the area of interest may be a source of error if distant disease is present.

In some patients, SPECT imaging is helpful to better characterize the presence, location and extent of disease. SPECT imaging should be performed as recommended by the camera manufacturer. Typical acquisition and processing parameters are 360° circular orbit, 60–120 stops, 64 × 64 × 16 or greater matrix, and 10–40 sec/stop. An equivalent total number of counts should be acquired if continuous acquisition is used.

A pinhole collimator may be used if very high-resolution images of a specific area are necessary. Approxi-

mately 75,000–100,000 counts should be obtained for pinhole collimator views. Zoom magnification or a converging collimator may also be used to improve resolution, particularly when small structures or pediatric patients are being imaged. The physician interpreting the image should be notified when collimators that introduce distortion, such as a pinhole collimator, are used.

Other views, such as lateral, oblique or tangential, and special views such as frog-leg views of the hips or sitting-on-detector (caudal) views of the pelvis are obtained, when necessary.

F. Interventions

The pelvis can be difficult to evaluate when there is overlying bladder activity. In patients with pelvic symptoms, one or more of the following additional views may better evaluate the pelvis.

1. Repeat images immediately after voiding
2. Sitting-on-detector (caudal) or oblique views
3. Lateral views
4. 24-hr delayed images
5. SPECT acquisition. Single or multiple rapid (5–10 min per acquisition) SPECT acquisition(s) are preferred to avoid artifacts caused by changing activity in the bladder. Bladder artifacts are exaggerated in the plane where the SPECT acquisition begins and ends.
6. Image immediately following catheterization of the bladder. (Note: Bladder catheterization should be reserved for patients in whom visualization of the pelvis is essential)

G. Processing

Generally no special processing of planar imaging is required. For general SPECT image processing guidelines, refer to the Society of Nuclear Medicine Procedure Guideline for General Imaging, *J Nucl Med* 1996: in press.

H. Interpretation/Reporting

A brief history and physical exam are important for proper interpretation of bone scintigraphy. In addition, review of the medical record and discussion with the referring physician will help to assure the appropriate special views are obtained. When appropriate, abnormalities detected on bone scintigraphy should be correlated with the results of other imaging studies.

1. The technical quality of the image should be assessed (inadequate, adequate but suboptimal, optimal study). If the study is not interpreted as technically optimal, the reason for the suboptimal quality should be specifically stated.
2. The target (bone)-to-background (soft tissues) ratio should be assessed.
3. Soft tissues should be examined for abnormalities (areas of increased or decreased tracer localization).
   a. Intensity of renal activity, renal morphology and tracer distribution in urinary collecting systems, should be noted.
   b. Residual tracer activity in the bladder following voiding should be evaluated.
4. The skeletal localization of the radiopharmaceutical should be surveyed and abnormalities reported (areas of increased or decreased tracer localization) including: (a) the anatomic location, (b) the distribution of abnormality (focal versus diffuse, etc.) and (c) the shape of the abnormality (round, fusiform, linear, etc.)
5. The findings on blood flow, blood-pool and SPECT studies should also be interpreted in accordance with Steps 1–4 (see above).

For general reporting guidelines, see the Society of Nuclear Medicine Procedure Guideline for General Imaging, *J Nucl Med* 1996: in press.

I. Quality Control

See the Society of Nuclear Medicine Procedure Guideline for General Imaging, *J Nucl Med* 1996: in press.

J. Sources of Error

1. Urine contamination or a urinary diversion reservoir.
2. Injection artifacts.
3. Prosthetic implants, radiographic contrast materials, or other attenuating artifacts which might obscure normal structures.
4. Homogeneously increased bony activity (e.g., "superscan").
5. Patient motion.
6. Greater than necessary collimator-to-patient distance.
7. Imaging too soon after injection, before the radiopharmaceutical has been optimally cleared from the soft tissues.
8. Restraint artifacts caused by soft-tissue compression.
9. Prior administration of a higher energy radionuclide (^{131}I, ^{67}Ga, ^{111}In), or of a ^{99m}Tc radiopharmaceutical that accumulates in an organ that could obscure or confound the skeletal activity.
10. Radioactivity extraneous to the patient.
11. Significant findings outside the area of interest may be missed if a limited study is performed.
12. Radiopharmaceutical degradation.
13. Changing bladder activity during SPECT of pelvic region.
14. Purely lytic lesions.
15. Pubic lesions obscured by underlying bladder activity.

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

None

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

1997

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Procedure Guideline for Lung Scintigraphy: 1.0

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Key Words: lung scintigraphy; pulmonary embolism; practice guidelines

J Nucl Med 1996; 37:1906–1910

PART I: PURPOSE

The purpose of this guideline is to assist nuclear medicine practitioners in recommending, performing, interpreting and reporting the results of lung scintigraphy for pulmonary embolism.

PART II: BACKGROUND INFORMATION AND DEFINITIONS

A. Aerosol Ventilation Scintigraphy
   A diagnostic imaging test that records the bronchopulmonary distribution of an inhaled radioactive aerosol within the lungs.
B. Gas Ventilation Scintigraphy
   A diagnostic imaging test that records the pulmonary distribution of a radioactive gas during breathing maneuvers.
C. Pulmonary Perfusion Scintigraphy
   A diagnostic imaging test that records the distribution of pulmonary arterial blood flow.
D. Lung Scintigraphy for Pulmonary Embolism
   A diagnostic imaging test that assesses pulmonary perfusion and often includes ventilation scintigraphy.

PART III: COMMON INDICATIONS

A. The most common indication for lung scintigraphy is to determine the likelihood of pulmonary embolism.
B. Less common indications (e.g., evaluation of lung transplantation, preoperative evaluation, right-to-left shunt evaluation) will be included in future versions of this guideline.

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PART IV: PROCEDURE

A. Patient Preparation
   1. A chest radiograph should be obtained before lung scintigraphy for pulmonary embolism. A routine chest radiograph obtained in both the posterior-anterior and lateral projections is preferred. A portable anterior-posterior chest radiograph is acceptable only if the patient cannot tolerate a routine chest radiographic examination. In patients who have no changes in signs or symptoms, a chest radiograph within 1 day of scintigraphy is adequate. A more recent chest radiograph (preferably within 1 hr) is necessary in patients whose signs and symptoms are changing.
   2. Before intravenous administration of the pulmonary perfusion radiopharmaceutical, the patient should be instructed to cough and to take several deep breaths. The patient should be in the supine position during injection, or in the case of a patient with orthopnea, as close to supine as possible.
B. Information Pertinent to Performing the Procedure
   1. In women of childbearing age, pregnancy and lactation status should be noted and the procedure performed in a manner to minimize radiation exposure.
   2. Pertinent clinical history includes, but is not limited to: (a) right-to-left shunt, (b) severe pulmonary hypertension, (c) chest pain, (d) dyspnea, (e) hemoptysis, (f) syncope, (g) symptoms of deep venous thrombosis, (h) oral contraceptive use, (i) recent surgery, (j) prior pulmonary embolism, (k) cancer, (l) congestive heart failure, (m) antecedent illness, (n) smoking and (o) intravenous drug abuse.
   3. Pertinent findings on physical examination include, but are not limited to: (a) vital signs, (b) chest