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Procedure Guideline for Gallium Scintigraphy in Inflammation

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Key Words: practice guidelines; gallium-67; inflammation imaging

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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 ^{67}Ga inflammation scintigraphy. Alternative techniques such as labeled leukocytes should be considered if clinically indicated.

PART II: BACKGROUND INFORMATION AND DEFINITIONS

Gallium-67 scintigraphy may include regional, whole-body, planar and SPECT scintigrams or any combination performed after intravenous injection of ^{67}Ga citrate.

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Note: All 26 SNM-approved procedure guidelines are available on the Society's home page. We encourage you to download these documents via the Internet at http://www.snm.org.

TABLE 1
Radiation Dosimetry for Adults

Radiopharmaceutical	Administered activity MBq (mCi)	Organ receiving largest radiation dose*† mGy (rad)	Effective dose*† mSv (rem)
^{67}Ga-citrate	150–220 i.v. (4–6)	0.2 Large lower intestine (0.74)	0.120 (0.444)

*ICRP 53, p. 142.
†per MBq (per mCi).
MIRD Committee Dose Estimate Report No. 2, Radiation Absorbed Dose for ^{66}Ga-, ^{67}Ga-, ^{68}Ga- and ^{72}Ga-citrate. *J Nucl Med* 1973;14:755–756. LLI = large lower intestine.

TABLE 2
Radiation Dosimetry for Children (5 yr old)

Radiopharmaceutical	Administered activity MBq/kg (mCi/kg)	Organ receiving largest radiation dose*† mGy (rad)	Effective dose*† mSv (rem)
^{67}Ga-citrate	1.5–2.6 i.v. (0.04–0.07)	0.72 Large lower intestine (2.6)	0.4 (1.5)

*ICRP 53, p. 142.
†per MBq (per mCi).
MIRD Committee Dose Estimate Report No. 2, Radiation Absorbed Dose for ^{66}Ga-, ^{67}Ga-, ^{68}Ga- and ^{72}Ga-citrate, *J Nucl Med* 1973;14:755–756.

PART III: COMMON INDICATIONS (*1*)

A. Whole-body survey to localize source of fever in patients with fever of unknown origin (FUO).
B. Diagnosing osteomyelitis and/or disk space infection. Gallium-67 is preferred over labeled leukocytes for disk space infection.
C. Detection of pulmonary and mediastinal inflammation/infection especially in the immunocompromized patient.
D. Evaluation and follow-up of active lymphocytic or granulomatous inflammatory processes such as sarcoidosis or tuberculosis.
E. Evaluation and follow-up of drug-induced pulmonary toxicity (e.g., bleomycin or amiodarone).

PART IV: PROCEDURE

A. Patient Preparation
Bowel preparation with oral laxatives and/or enemas prior to imaging will usually decrease the amount of activity with the bowel and reduce radiation dose. Routine use of a bowel preparation is optional.
B. Information Pertinent to Performing the Procedure
1. Recent hemolysis or blood transfusion, which can alter ^{67}Ga localization.
2. Recent surgery, diagnostic procedures or trauma.
3. Recent chemotherapy, radiation therapy or gadolinium administration for MRI.
4. History of immune suppression or malignancy.
5. Results of radiographs and other diagnostic tests.
C. Precautions
Lactation and pregnancy are relative contraindications. If the patient is willing to permanently discontinue breastfeeding and the gallium inflammation study is semi-elective, the patient should be asked to stop breastfeeding 2 wk prior to the gallium injection. This precaution will significantly decrease the radiation dose to the breast.

If the examination is urgent, the breastfeeding patient should be asked to discontinue breastfeeding for approximately 2–4 wk following the gallium injection. This precaution will significantly decrease the radiation dose to the nursing infant.

D. Radiopharmaceutical
1. Gallium-67-citrate has a physical half-life of 78 hr. The principal photopeaks are: 93 keV (40%), 184 keV (24%), 296 keV (22%) and 388 keV (7%). The largest organ absorbed radiation dose (about 750 mrems/mCi) is to the wall of the lower large intestine (LLI). For the adult, the usual administered activity is 150–220 MBq (4–6 mCi) intravenously (Table 1). The usual administered activity in children (Table 2) is 1.5–2.6 MBq/kg (0.04–0.07 mCi/kg) with a minimum dose of 9–18 MBq (0.25–0.5 mCi). The maximum administered activity in children should not exceed the maximum administered activity for adults.
2. Normal distribution: About 10%–25% of the injected dose is excreted by the kidneys during the first 24 hr after injection. After this time, the principal route of excretion is the gastrointestinal tract. By 48 hr after injection, about 75% of the injected dose remains in the body and is equally distributed among the liver, bone and bone marrow and soft tissues. Normal distribution is variable with increased localization in the nasopharynx, lacrimal glands, thymus, breasts, liver and spleen.

E. Image Acquisition
1. A large field of view multipeak gamma camera equipped with a medium-energy, parallel-hole collimator is preferred. A low-energy collimator cannot be used. Energy discrimination is accomplished by using 15%–20% windows centered around two (93 and 184 keV), or three (93, 184 and 296 keV) of the principal photopeaks. The 93-keV window is usually not used within 24–36 hr of a ^{99m}Tc-tracer injection or in very obese patients.
2. Scintigrams are generally obtained 18–72 hr after injection of the radiopharmaceutical. Delayed scintigrams at 96 hr or later may be necessary for accurate interpretation and are particularly helpful in the abdomen when normal colonic and renal activity can make scintigram interpretation difficult. Early 4–6-hr scintigrams can be helpful in cases of acute inflammation to avoid extensive bowel activity.
3. For whole-body scintigraphy, anterior and posterior scintigrams are obtained. These scintigrams should be acquired for 1.5–2.0 million counts/whole body, or 25–35 min, whichever comes first. For adults, this corresponds to a minimum scan speed of 6–8 cm/min. For regional scintigrams of the chest, they are obtained for 250,000–1,000,000 total counts (5–20 min). Regional scintigrams of the remainder of the body should be obtained for the same time. The large range in counts obtained (and the maximum time per image) is necessary because what is practical depends on: (a) the time after the injection that the images are obtained and (b) the ability of the patient to cooperate.

4. SPECT Imaging
   See Society of Nuclear Medicine Procedure Guideline for General Imaging.

F. Interventions
   None. Bowel preparation is optional.

G. Processing
   See Society of Nuclear Medicine Procedure Guideline for General Imaging.

H. Interpretation/Reporting
   1. Osteomyelitis which may be complicated by other osseous pathology (*2–5*). In general, for diagnosing osteomyelitis, ^{67}Ga scintigrams are interpreted together with ^{99m}Tc bone scintigrams according to the following criteria:
      a. The combined bone/gallium study is negative for infection in untreated patients when: (a) gallium scintigraphy is negative, regardless of the bone scintigraphy results, or (b) the activity on both studies is spatially congruent, and the relative intensity of gallium activity is less than that of bone activity.
      b. The combined bone/gallium study is positive for infection when: (a) the activity on both studies is spatially congruent and the relative intensity of gallium activity is greater than that of bone activity, or (b) the activity on both studies is spatially incongruent with gallium activity exceeding bone activity in at least one area.
      c. The combined bone/gallium study is equivocal for infection when the activity on both studies is spatially congruent and the relative intensity of the gallium activity is equal to the bone activity. This result can occur in patients taking antibiotics and are partially treated.
   2. For immunocompromized patients (AIDS, post-chemotherapy and transplant recipients), gallium scintigraphy has proved most useful in detecting pulmonary infections (*6–10*).
      a. Negative gallium scintigraphy in a nontreated patient excludes infection with a high degree of certainty.
      b. Negative gallium scintigraphy in an AIDS patient with an abnormal chest radiograph suggests the diagnosis of Kaposi's sarcoma.
      c. Increased hilar and mediastinal lymph node activity is frequently caused by *mycobacterium avium intracellulare*, *mycobacterium tuberculosis* and lymphoma.
      d. Focal increased pulmonary parenchymal activity usually indicates neoplasm or pneumonia. *Pneumocystis carinii* pneumonia (PCP) may occasionally present in this fashion.
      e. Diffuse increased pulmonary activity
         1. The intensity of activity usually corresponds to the degree of active inflammation and may be graded with respect to hepatic localization. (Note: hepatic uptake may be decreased in AIDS and acute lymphocytic leukemia).
         2. In general, more intense activity is likely to be PCP. While less intense activity can be seen in PCP, it is also associated with other opportunistic infections such as cytomegalovirus (CMV), fungal pneumonia and partially treated PCP.
         3. Increased pulmonary activity predominantly in the upper lungs is associated with PCP in patients receiving aerosolized pentamidine.
   3. Miscellaneous patients with abnormal pulmonary activity
      a. Additional causes for diffuse increased pulmonary activity include idiopathic pulmonary fibrosis, sarcoidosis, interstitial pneumonitis, drug toxicity, radiation pneumonitis, lymphangitic metastatic cancer and reaction to contrast (lipiodol) in the lungs.
      b. Additional causes for increased hilar and mediastinal lymph node activity include sarcoidosis, tuberculosis and lymphoma.

I. Quality Control
   Gallium-67 is available in unit dose or multidose vials as ^{67}Ga-citrate, ready for injection. Refer to Society of Nuclear Medicine Procedure Guideline for Imaging with Radiopharmaceuticals for more details. Gamma camera quality control measures will vary from camera to camera. Spatial registration of photons detected must be checked periodically. Refer to Society of Nuclear Medicine Procedure Guideline for General Imaging for more details.

J. Sources of Error (*1,11*)
   1. Residual bowel activity is probably the most common cause for both false-positive and false-negative interpretations.
   2. Hilar nodal localization (usually low-grade) can be seen as a normal variant in adult patients, particularly in smokers.
   3. In children and teenagers, increased activity can be seen in thymic hyperplasia postchemotherapy. Below 2 yr of age, increased thymic activity is common.
   4. Gadolinium administered for MRI enhancement within 24 hr prior to gallium injection has been observed to decrease gallium localization (*11*).
   5. Saturation of iron binding transferrin sites (e.g., hemolysis or multiple blood transfusions) causes altered gallium distribution (*1*).
   6. Gallium-67 uptake at sites of bone repair secondary to healing fractures or prior pin sites, loose prosthesis or after successful treatment of osteomyelitis may complicate interpretation in patients with suspected osteomyelitis.
   7. Recent chemotherapy and radiation therapy.
   8. Desferrioxamine therapy.
   9. Increased breast activity.
   10. Hilar, submandibular and diffuse pulmonary localization in patients with lymphoma during therapy.
   11. Radiation sialadenitis causing increased localization.

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

A. Efficacy related to use of ^{111}In leukocytes or ^{99m}Tc leukocytes in many infections.
B. Minimum administered activity in children.

PART VII: CONCISE BIBLIOGRAPHY

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Procedure Guideline for Indium-111-Leukocyte Scintigraphy for Suspected Infection/Inflammation

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Key Words: practice guidelines; indium-111-leukocytes; inflammation/infection imaging

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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 ^{111}In-labeled leukocyte scintigraphy.

PART II: BACKGROUND INFORMATION AND DEFINITIONS

Indium-111-leukocyte scintigraphy is a diagnostic imaging test which displays the distribution of radiolabeled leukocytes in the body. Regional, whole-body, planar and/or SPECT

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