Coverage Position

CIGNA HealthCare covers nuclear imaging scintigraphy (including single-photon emission computed tomography [SPECT] and SPECT with concurrently-acquired computed tomography [SPECT/CT]) as medically necessary for ANY of the following when other imaging studies are inconclusive or contraindicated:

- bone and skeletal disorders
- brain disorders (e.g., dementia including Alzheimer’s disease (AD), cerebrovascular disease, epilepsy, encephalitis, head injury, central nervous system disorders)
- gastrointestinal disorders
- hepatobiliary and hepatosplenic disorders
- infections and inflammation
- lung disorders
- parathyroid disorders
- renal and urinary disorders
- acute and subacute scrotal pain (i.e., testicular torsion, epididymitis, orchitis)
- thyroid disorders
- tumors

CIGNA HealthCare covers SPECT myocardial perfusion imaging (MPI) OR MUGA scanning (multiple gated acquisition, equilibrium radionuclide angiography/ventriculography ERNA, RVG, or gated blood pool imaging), as medically necessary for ANY of the following:
• detection of obstructive coronary artery disease (CAD) for EITHER of the following:
  ➢ patients at intermediate CAD risk on standardized risk assessment
  ➢ patients at high risk factor for CAD (e.g., diabetes mellitus, peripheral or cerebral vascular disease).

• risk stratification for ANY of the following:
  ➢ post myocardial infarction patients before discharge
  ➢ patients with chronic stable CAD to differentiate a low risk state that can be managed medically from a high-risk state for which coronary revascularization should be considered
  ➢ acute coronary syndrome patients when a diagnosis of acute myocardial infarction has been excluded but a strong suspicion of ischemia remains
  ➢ before noncardiac surgery in patients with known CAD or those considered at high risk for CAD

• evaluation of a change in symptoms suggestive of worsening ischemia in patients with a previous invasive treatment for CAD

CIGNA HealthCare does not cover nuclear imaging scintigraphy including SPECT or SPECT/CT for any of the following because it is considered experimental, investigational or unproven:

• chronic fatigue syndrome
• multiple myeloma
• psychiatric and neuropsychiatric disorders
• scrotal tumors, chronic inflammation or cryptorchidism
• screening for coronary artery disease

General Background

Nuclear medicine is a subspecialty within the field of radiology. X-ray and nuclear medicine imaging share in common the use of ionizing radiation. X-ray images are produced by recording the differential absorption of x-rays by body tissues. Nuclear medicine images are obtained by mapping the distribution of radioactivity of an administered radiopharmaceutical within the body. Gamma-rays and x-rays are photons, or electromagnetic radiation, that can penetrate matter and be detected by an external detection system.

In order to produce a nuclear medicine image, several steps must be completed. First, a pharmaceutical with appropriate biological behavior must be chosen. This compound must be successfully bound to some radioactive material without changing the biological behavior of the original pharmaceutical. The resulting radioactive compound is referred to as a radiopharmaceutical. Once it has been administered to the patient, radiation detectors are used to record the internal spatial distribution of the radiopharmaceutical in the body in two or three dimensions. The detectors used are usually some kind of scintillation detector, either a large field of view gamma camera with one to three heads, or a ring detector. Temporal changes in distribution can also be recorded, creating a dynamic image. In general, it is functional information that is derived from the distribution of the radiopharmaceutical, whether from dynamic images or ‘static’ images recorded at a single time point. Additional information, in both imaging and numerical form, is often obtained from further computer processing of the original images.

The ultimate goal of nuclear medicine is to provide an accurate, three-dimensional (3D) map of the distribution of a radiopharmaceutical within a patient, and possibly also to measure changes in distribution with time.

Emission computed tomography (ECT) provides an in vivo three-dimensional distribution of radiopharmaceuticals within the body, generated from a set of two-dimensional projectional images. ECT is considered functional imaging, whereas magnetic resonance imaging (MRI) or computed tomography (CT) are considered anatomical. ECT improves image contrast and quantification and includes single-photon emission computed tomography (SPECT) and positron emission tomography (PET). SPECT is more readily available in practice than PET because it utilizes commercially available isotopes and does
not require an on-site cyclotron. SPECT involves the detection of gamma rays emitted singly (single-photon) from radionuclides such as technetium-99m (Tc-99m) and thallium-201 (Tl 201).

Conventional planar imaging provides only a two-dimensional projection of a three-dimensional distribution of activity. Planar imaging may be used for patients who do not tolerate the position that must be maintained during a SPECT acquisition, those who have difficulty coping with the larger SPECT camera being so close to the body, or those with large body habitus that surpasses the weight and size limits of SPECT systems. SPECT scintigrams allow 3D information to be gained in addition to standard planar views. They are used to give depth information (e.g., in kidney studies) or aid localization of a particular lesion (e.g., for bone scintigrams). Alternatively, SPECT can be used for myocardial studies or various brain imaging techniques (e.g., for diagnosis of dementia and evaluation of cerebral blood flow). More recently, dual-headed cameras have entered the market, and these are capable of automatically acquiring whole-body scintigrams in one pass. They have reduced the acquisition time for many studies when compared with the single-headed cameras, including SPECT sequences, while allowing the simultaneous collection of two or more images (e.g., anterior and posterior or lateral or oblique views). Some of these dual-headed cameras have a fixed geometry of 180° separation between the two heads, whereas the newest that have variable angle gantries are especially useful for the increasing cardiac workload (Grainger, et al., 2003).

Nuclear medicine images can assist the physician in diagnosing diseases. Tumors, infection and other disorders can be detected by evaluating organ function. Some applications of nuclear medicine include:

- analysis of kidney function
- imaging blood flow and function of the heart
- scanning lungs for respiratory and blood-flow problems
- identification of gallbladder blockage
- bone evaluation for fracture, infection, arthritis or tumor
- determining the presence or spread of cancer
- identification of bleeding into the bowel
- locating the presence of infection
- measuring thyroid function to detect an overactive or underactive thyroid

(Radiology Society of North America, 2005)

U.S. Food and Drug Administration (FDA)
Radiopharmaceuticals and imaging systems are regulated by the U.S. Food and Drug Administration (FDA). Premarket 510(k) notification is required by the FDA for an emission computed tomography diagnostic device or nuclear tomography system, which are Class II medical devices. Radiopharmaceutical approvals may or may not specify the types of imaging systems they can be used with or the types of conditions or diagnoses they can be used to help detect.

Bone / Skeletal - Literature Review
Bone or skeletal scintigraphy is performed for numerous indications, including but not limited to: primary and metastatic bone neoplasms; occult fracture; osteomyelitis; arthritides; bone viability [grafts, infarcts, osteonecrosis]; reflex sympathetic dystrophy; otherwise unexplained bone pain; and distribution of osteoblastic activity before radionuclide therapy for bone pain (American College of Radiology [ACR], 2003; Society of Nuclear Medicine [SNM], 2003).

Skeletal scintigraphy is a sensitive method for detecting numerous conditions involving the skeletal system. Although certain patterns are suggestive of individual disease entities, correlation of abnormal activity with clinical information, conventional radiographs, and other imaging techniques, including CT, magnetic resonance imaging (MRI), and other radiopharmaceutical imaging studies, is frequently helpful for diagnosis.

Radionuclide scanning has become a useful imaging adjunct in the diagnosis of osteomyelitis. While x-ray and CT scans give a structural or anatomical picture, radionuclide scanning gives a more physiological picture. Radionuclide scanning also is useful in patients with metallic implants in whom CT and MRI scans are of limited value because of contraindications and metallic-generated artifact. The three most commonly used radioisotopes are Tc-99m phosphate, gallium 67 citrate (67Ga), and indium...
$^{111}\text{In}$-labeled leukocytes. Tc-99m phosphate can detect osteomyelitis within 48 hours after clinical onset of infection (Canale, 2003).

Bone scintigraphy using Tc-99m methylene diphosphonate (MDP) can be used to exclude infection or neoplasm in children with joint symptoms (Grainger, et al., 2003).

Spondylolysis usually can be detected as a defect in the pars interarticularis on a 45-degree oblique x-ray of the lumbar spine. Lateral x-rays are used to document the degree of spondylolisthesis. In children and adolescents, SPECT is useful to show a pars defect that is not apparent on x-ray and is useful to determine whether a spondylolytic lesion is acute enough to merit immobilization (Frontera, et al., 2002). A radionuclide bone scan is valuable to determine if more than one skeletal site is involved with Paget's disease (Noble, 2001). Radionuclide bone scans are more sensitive than standard radiographs in identifying metastatic lesions (other than the plasmacytomas of multiple myeloma) and are also useful in characterizing the spondylolysis associated with ischemic spondylolisthesis. Nuclear medicine studies are sometimes helpful in identifying abscesses and osteomyelitis (Noble, 2001).

**Brain - Literature Review**

Radionuclide imaging of the brain requires radiopharmaceuticals that cross the blood–brain barrier. Clinical applications include but are not limited to: dementia including Alzheimer’s disease (AD), cerebrovascular disease, epilepsy, encephalitis, head injury, and other less common disorders that result in abnormal cerebral perfusion. SPECT can be used to image uptake at neurotransmitter receptors (Grainger, et al., 2003; ACR, 2003; SNM, 1999, 2003).

In acute stroke, SPECT with Tc-99m hexamethylpropyleneamineoxime (HMPAO) or Tc-99m ethyl cysteinate dimer (ECD) will show a perfusion defect as soon as vascular occlusion occurs but will not exclude intracranial hemorrhage. HMPAO SPECT is superior to clinical examination and CT in predicting short-term outcome following stroke, and quantitation of degree of ischemia will predict risk of intracranial hemorrhage following intra-arterial thrombolysis. Diffusion-weighted MRI may be the most sensitive imaging study for acute stroke; however, SPECT imaging can identify areas of decreased blood flow in patients with acute infarcts (Grainger, et al. 2003; Goetz, 2003).

In general, patients have an imaging study at the time of the initial diagnosis of dementia. A repeat of the imaging study is typically considered in patients with acute deterioration in function, particularly with development of new focal neurologic signs or any history of head trauma. A CT scan of the head or an MRI may be performed. SPECT scanning may also have a role in the evaluation of patients with dementia. Characteristic patterns have been described in AD and Pick’s disease but have not been fully substantiated with clinicopathologic correlations. The test involves the infusion of a radionuclide followed by a relatively brief period of imaging. It requires some patient cooperation, but most patients can tolerate the procedure. At this stage, results should be considered supportive but not diagnostic. SPECT scans are not part of a routine evaluation at this stage (Noble, 2001). Zakzanis et al. (2003) notes the most frequently indexed aspects of physiological function in Alzheimer’s disease (AD) include glucose metabolism and blood flow as measured with PET and SPECT. It is important to note that each of these imaging methods has its strengths and limitations in clinical practice. Accordingly, these various techniques are considered complementary to one another in terms of diagnosis and documenting the clinical progression of disease in general. SPECT of the Alzheimer brain primarily addresses resting-state regional cerebral blood flow using both single- and multi-head gamma-camera based systems.

In severe head trauma, SPECT may characterize prognosis of focal lesions as well as cases of more widespread diffuse axonal injury (Goetz, 2003).

CT, MRI, and electroencephalography (EEG) are the primary noninvasive methods used to localize an epileptic focus but do not always identify a lesion. These patients may require invasive placement of depth electrodes to definitively elucidate a seizure focus. SPECT has been helpful in demonstrating regional decreased cerebral blood flow within a seizure focus between seizures and increased regional ictal cerebral blood flow. HMPAO is the SPECT radionuclide of choice. There is an additional increased sensitivity if an ictal SPECT scan can be obtained. Tc-99m HMPAO SPECT reveals hypoperfusion in the epileptogenic temporal lobe during the interictal state in over 50% of patients with temporal lobe epilepsy.
Research suggests that a more stable SPECT imaging agent, ECD, which is chemically more stable than HMPAO, has the potential to become the radionuclide of choice (Goetz, 2003).

SPECT, using Tc-99m HMPAO, is a sensitive technique to study regional cerebral blood flow. SPECT is particularly useful in investigating cerebral vascular disease in children (e.g., systemic lupus erythematosus), as well as herpes encephalitis, and for localization of focal epileptiform discharges and recurrent brain tumors (Behrman, et al., 2004).

The National Institute for Health and Clinical Excellence Clinical Guideline on Parkinson’s disease (June, 2006) states SPECT should be considered for people with tremor where essential tremor cannot be clinically differentiated from Parkinsonism.

For other indications (e.g., neuropsychiatric disorders, chronic fatigue syndrome), the findings of SPECT brain perfusion imaging have not been fully characterized (ACR; SNM; Frontera, et al., 2002).

**Brain - Professional Societies/Organizations**

**American Academy of Neurology:** Using clinical evaluation as the comparator, five class III studies demonstrated that (1r)-2 β-carbomethoxy-3 β-(4-iodophenyl)tropane (β-CIT) and 123I iodobenzamide (IBZM) SPECT had 8% to 100% specificity in identifying clinically diagnosed PD patients, as compared to other parkinsonian syndromes. Sensitivity varied from 30 to 100%. AAN concluded β-CIT and IBZM SPECT are possibly useful in distinguishing PD from essential tremor. There is insufficient evidence to determine if these modalities are useful in distinguishing PD from other forms of Parkinsonism (Suchowersky, et al., 2006).

In determining brain death in adults, Tc-99m HMPAO brain scan should show no uptake of isotope in brain parenchyma (“hollow skull phenomenon”) (AAN, 2003).

Near infrared spectroscopy, nuclear medicine (SPECT and PET), and functional MRI are other major imaging technologies not discussed in this neuroimaging of the neonate practice parameter because of lack of data; these technologies are under evaluation for use in the assessment of the developing brain (Ment, et al., 2002).

For the differentiation of AD versus non-AD dementia, hypoperfusion in the temporal–parietal lobe(s) was reported to be 86-95% sensitive and 42-73% specific. Although encouraging, these figures are not consistently better than those obtained by diagnosis with established clinical criteria (Knopman, et al., 2001).

Functional imaging modalities such as functional MRI (fMRI), SPECT, or PET are currently only research tools in the evaluation of autism. There is no evidence to support a role for functional neuroimaging studies in the clinical diagnosis of autism at the present time (AAN, 2000).

There was insufficient evidence to make any recommendations regarding the role of SPECT scans or evoked potentials in children with cerebral palsy (Ashwal, et al., 2004).

**American Academy of Pediatrics (AAP):** Brain imaging studies and electroencephalography do not show reliable differences between children with Attention-Deficit/Hyperactivity Disorder (ADHD) and controls (AAP, 2000).

**American Heart Association:** SPECT cerebral blood flow studies can be used to determine the relative risks of hemorrhage following thrombolysis of acute stroke patients, whatever the time after onset of symptoms (grade A) (Latchaw, et al., 2003).

**American Psychiatric Association (APA):** Preliminary evidence indicates that there may be a use for SPECT in the diagnosis of Alzheimer’s disease (Rabins, 2006).

APA Psychiatric Evaluation of Adults APA Guideline (2006) states that “neuroimaging techniques are currently used in identifying central nervous system processes such as infection, malformations,
neuroimaging in psychiatric evaluation. In cognitive disorders of late life, such as Alzheimer's disease, neuroimaging techniques have been evaluated for use as surrogate markers for the microscopic neuropathologies that characterize the illness. Functional neuroimaging with positron emission tomography or single-photon emission computed tomography has demonstrated an association between reduced regional activity (metabolism or perfusion) in temporoparietal regions and the presence and severity of Alzheimer's disease, whereas other dementing illnesses do not show this temporoparietal feature. The reproducibility of these findings has enhanced the differentiation between Alzheimer's disease and other dementing illnesses. Ongoing work aims to confirm the clinical utility of such information.

In patients with schizophrenia and mood and anxiety disorders, structural and functional neuroimaging studies have reported differences between patients and healthy control persons as well as differences in some patient subgroups and in responders and nonresponders to some treatments. Nevertheless, the clinical utility of neuroimaging techniques for planning of individualized treatment has not yet been shown. Further research is needed to demonstrate a clinical role for structural and functional neuroimaging in establishing psychiatric diagnoses, monitoring illness progression, and predicting prognoses."

American College of Radiology (ACR): Primary indications include: seizures, cranial nerve dysfunction, diplopia, ataxia, acute and chronic neurologic deficits, suspicion of neurodegenerative disease, primary and secondary neoplasm, aneurysm, cortical dysplasia and other morphologic brain abnormalities, vasculitis, encephalitis, brain maturation, headache, mental status change, hydrocephalus, ischemic disease and infarction, suspected pituitary dysfunction, inflammation or infection of the brain or meninges or their complications, postoperative evaluation, demyelination and dysmyelination disorders, vascular malformations, and arterial or venous/dural sinus abnormalities. Extended indications include: suspicion of acute intracranial hemorrhage or evaluation of chronic hemorrhage, neuroendocrine dysfunction, functional imaging, brain mapping, blood flow and brain perfusion study, image guidance for intervention or treatment planning, spectroscopy (including the evaluation of brain tumor, infectious processes, brain development and/or degeneration, and ischemic conditions), and post-traumatic conditions (ACR, 2003).

Cardiac - Literature Review
Cardiac nuclear imaging is used to examine the anatomy and function of the heart. There are several types of cardiac nuclear imaging studies:

**SPECT Myocardial Perfusion Imaging (MPI):** SPECT MPI scanning gives you two key results. One is perfusion, by comparing rest and stress images to look for fixed or reversible defects. The other is function; by giving you wall motion, including ejection fraction. SPECT is preferable to planar for myocardial perfusion scintigraphy. Currently utilized myocardial perfusion tracers for SPECT imaging include Thallium-201 (Tl-201) and two Tc-99m agents (Tc-99m sestamibi and Tc-99m tetrofosmin). Some radiopharmaceutical doses fall outside of manufacturer's package insert guidelines, but are now commonly used in the clinical practice of nuclear cardiology. There are other abnormal findings that provide additional information beyond that provided by the perfusion pattern alone, including lung uptake of tracer (particularly Tl-201) and transient ischemic dilation of the left ventricle. Both have been associated with angiographically extensive and severe coronary artery disease (CAD).

SPECT MPI is usually accomplished in an outpatient setting. There are only two indications for two-day protocols. For technetium-based studies, they may be required when obesity requires large doses of isotope. For thallium scanning, a second dose may be required at 24 hours to look for viable myocardium when planning revascularization. Dual isotope scans using Thallium and technetium are very efficient (rest and then stress portions can be done in as little as 90 minutes.

SPECT MPI can be performed at rest, or under stress caused by exercise or pharmacologically. Exercise or pharmacological stress Ti-201 or Tc-99m sestamibi SPECT MPI in patients with chest pain yields sensitivity for detecting CAD in the 85 to 90% range. Specificity for excluding CAD is in the 90% range when electrocardiography (EKG)-gated SPECT MPI is used. Exercise SPECT MPI and pharmacological SPECT MPI both yield sensitivities and specificities for CAD detection that are superior to those of exercise ECG testing alone. Stress SPECT MPI can be used for assessment of prognosis of patients evaluated for CAD. Data reported from the literature demonstrate that patients with normal regional
myocardial perfusion and normal left ventricular function on gated SPECT scans have an excellent prognosis, whereas patients with abnormal scans have an increased rate of cardiac death and nonfatal infarction during follow-up. The greater the extent of stress-induced hypoperfusion and reversibility, the greater the probability of an event.

The incorporation of ECG-gated SPECT imaging into a SPECT acquisition is now standard of care in MPI and is recommended as standard by contemporary guidelines. The addition of left ventricular (LV) function data to the perfusion information provides incremental and independent prognostic information as well as being of practical importance in management decisions. Gated SPECT MPI has also been an important advance in helping to differentiate attenuation artifacts from infarct, as regions with persistent low counts that show normal motion and thickening represent soft tissue artifacts rather than scar. Thus, gated SPECT MPI has improved the specificity of perfusion imaging for ruling out CAD, particularly in women (Zipes, et al., 2005; American Society of Nuclear Cardiology [ASNC], 2006).

Equilibrium Radionuclide Angiography or Ventriculography (i.e., Gated Blood Pool Imaging): The equilibrium technique is often referred to as multiple gated acquisition (MUGA) scanning, or by ERNA or RVG. In equilibrium RVG studies, data are recorded in a computer system synchronized with the R wave of the patient's ECG, similar to ECG-gated SPECT. It is used to determine global and regional measures of ventricular function (primarily LV function) at rest and/or during exercise stress or pharmacologic intervention. These measures of ventricular function may include evaluations of ventricular wall motion, EF, and other parameters of systolic and diastolic function. Most commonly, Tc-99m labeling is applied to red blood cells or albumin. Image contrast is usually better with Tc-99m-labeled red blood cells, but Tc-99m-labeled albumin is preferable in patients in whom red blood cell labeling may be difficult (Zipes, et al., 2005; ASNC, 2006).

First-pass Radionuclide Angiography or Ventriculography: First-pass can also assess LV and right ventricular (RV) function at rest or during stress (evaluation of wall motion, ejection fraction [EF], and other systolic and diastolic parameters); also to assess and measure left-to-right shunts. First pass studies are very rarely performed any more. They have been replaced by RVG (Zipes, et al., 2005; ASNC, 2006).

Cardiac - Professional Societies/Organizations

*American Society of Nuclear Cardiology (ASNC): ASNC Imaging Guidelines for Nuclear Cardiology Procedures addresses some of the following points: (July, 2006)

MPI SPECT is preferable to planar for myocardial perfusion scintigraphy. Myocardial Perfusion SPECT evaluates regional myocardial perfusion and function. The majority of stress myocardial perfusion radionuclide studies currently are acquired as gated SPECT data. However, there is mounting evidence that the information content of the post-stress acquisition may be different from that of the resting data, most likely due to post-ischemic stunning of myocardium. Providing that there is adequate count density, particularly with regard to the lower dose acquisitions, both stress and rest SPECT perfusion studies may be acquired as gated data sets. Because of the substantial benefit of the information obtained, gated studies of ventricular function should be a routine part of myocardial perfusion SPECT. Exercise is the preferred stress modality in patients who are able to exercise to an adequate workload (at least 85% of age-adjusted maximal predicted heart rate and five estimated metabolic equivalents of exercise (METS).

Exercise stress test indications:
- detection of obstructive CAD in:
  - patients with an intermediate pre-test probability of CAD based on age, gender and symptoms, and in
  - patients with high risk factors for CAD (e.g. diabetes mellitus, peripheral or cerebral vascular disease).
- risk stratification of post myocardial infarction patients before discharge (submaximal test at 4-6 days), early (symptom limited at 14-21 days) or late (symptom limited at 3-6 weeks) after discharge.
- risk stratification of patients with chronic stable CAD into a low-risk category that can be managed medically, or into a high-risk category that should be considered for coronary revascularization.
risk stratification of low-risk acute coronary syndrome patients (without active ischemia and/or heart failure 6-12 hours after presentation), and of intermediate-risk acute coronary syndrome patients 1-3 days after presentation (without active ischemia and/or heart failure symptoms).

- risk stratification before noncardiac surgery in patients with known CAD or those with high risk factors for CAD.
- to evaluate the efficacy of therapeutic interventions (anti-ischemic drug therapy or coronary revascularization) and in tracking subsequent risk based on serial changes in myocardial perfusion in patients with known CAD.

Absolute contraindications:
- high risk unstable angina. However, patients with suspected unstable angina at presentation, who are otherwise stable and pain free, can undergo exercise stress testing.
- decompensated or inadequately controlled congestive heart failure
- uncontrolled hypertension (blood pressure >200/110 mm of Hg)
- uncontrolled cardiac arrhythmias (causing symptoms or hemodynamic compromise)
- severe symptomatic aortic stenosis
- acute pulmonary embolism
- acute myocarditis or pericarditis
- acute aortic dissection
- severe pulmonary hypertension
- acute myocardial infarction (<4 days)

Relative contraindications:
- known left main coronary artery stenosis
- moderate aortic stenosis
- hypertrophic obstructive cardiomyopathy or other forms of outflow tract obstruction
- significant tachyarrhythmias or bradyarrhythmias
- high degree atrioventricular block
- electrolyte abnormalities
- mental or physical impairment leading to inability to exercise adequately
- if combined with imaging, patients with complete LBBB, permanent pacemakers and ventricular pre-excitation (W-P-W) should preferentially undergo pharmacological vasodilator stress test (not dobutamine stress test)

Exercise stress testing has a limited value in patients who cannot achieve an adequate heart rate and blood pressure response due to a noncardiac physical limitation such as pulmonary, peripheral vascular, musculoskeletal abnormalities or due to lack of motivation. These patients should undergo pharmacologically-induced stress imaging.

Equilibrium Radionuclide Angiocardiography (ERNA) – ERNA is used to determine global and regional measures of ventricular function (primarily LV function) at rest and/or during stress. These measures of ventricular function may include evaluations of ventricular wall motion, EF, and other parameters of systolic and diastolic function.

First-Pass Radionuclide Angiography (FPRNA) – FPRNA is performed: to assess LV and right ventricular (RV) function at rest or during stress (evaluation of wall motion, EF, and other systolic and diastolic parameters); and to assess and measure left-to-right shunts.

*American College of Cardiology Foundation (ACCF)/American Society of Nuclear Cardiology (ASNC): ACCF/ASNC Appropriateness Criteria for SPECT Myocardial Perfusion Imaging (SPECT MPI) complements existing guidelines and performance measures, examining indications for SPECT MPI in the context of scientific evidence, physician judgment, patient specifics and the health care environment (Brindis, et al., 2005). The Working Group devised clinical scenarios to score each indication. They were rated as follows:
- “Appropriate” test for that specific indication (test is generally acceptable and is a reasonable approach for the indication).
• “Uncertain” or possibly appropriate test for that specific indication (test may be generally acceptable and may be a reasonable approach for the indication. Uncertainty also implies that more research and/or patient information is needed to classify definitively the indication as appropriate and to update the criteria.)
• “Inappropriate” test for that specific indication (test is not generally acceptable and is not a reasonable approach for the indication).

The panel of experts from the ACC and ASNC rated 52 indications. The experts ranked 27 indications appropriate (52%) and 12 possibly appropriate or uncertain (23%), recommending reimbursement for those 39 indications (75%). They found 13 indications to be inappropriate (25%) and encourage physicians to prepare to document exceptions when ordering an SPECT MPI for one of those indications. The ACCF/ASNC appropriateness review of SPECT MPI resulted in the following 52 indications:

Detection of CAD: Symptomatic, Evaluation of Chest Pain Syndrome is:
• Appropriate, if intermediate pre-test probability of CAD and ECG interpretable and able to exercise
• Appropriate, if intermediate pre-test probability of CAD and ECG uninterpretable or unable to exercise
• Appropriate, if high pre-test probability of CAD and ECG interpretable and able to exercise
• Appropriate, if high pre-test probability of CAD and ECG uninterpretable OR unable to exercise
• Uncertain, if low pre-test probability of CAD and ECG uninterpretable or unable to exercise
• Inappropriate, if low pre-test probability of CAD and ECG interpretable and able to exercise

Detection of CAD: Symptomatic, Acute Chest Pain (in Reference to Rest Perfusion Imaging) is:
• Appropriate, if intermediate pre-test probability of CAD and ECG – no ST elevation AND initial cardiac enzymes negative
• Inappropriate, if high pre-test probability of CAD and ECG – ST elevation

Detection of CAD: Symptomatic, New-Onset/Diagnosed Heart Failure With Chest Pain Syndrome is:
• Appropriate, if intermediate pre-test probability of CAD

Detection of CAD: Asymptomatic (Without Chest Pain Syndrome) is:
• Inappropriate, if low CHD risk (Framingham risk criteria)
• Uncertain, if moderate CHD risk (Framingham)

Detection of CAD: Asymptomatic (Without Chest Pain Syndrome), New-Onset or Diagnosed Heart Failure or LV Systolic Dysfunction Without Chest Pain Syndrome is:
• Appropriate, if moderate CHD risk (Framingham) and no prior CAD evaluation AND no planned cardiac catheterization

Detection of CAD: Asymptomatic (Without Chest Pain Syndrome), Valvular Heart Disease Without Chest Pain Syndrome is:
• Uncertain, if moderate CHD risk (Framingham) and to help guide decision for invasive studies

Detection of CAD: Asymptomatic (Without Chest Pain Syndrome), New-Onset Atrial Fibrillation is:
• Uncertain, if low CHD risk (Framingham) and part of the evaluation
• Appropriate, if high CHD risk (Framingham) and part of the evaluation

Detection of CAD: Asymptomatic (Without Chest Pain Syndrome), Ventricular Tachycardia is:
• Appropriate, if moderate to high CHD risk (Framingham)

Risk Assessment: General and Specific Patient Populations, Asymptomatic
• Inappropriate, if low CHD risk (Framingham)
• Uncertain, if moderate CHD risk (Framingham)
• Appropriate, if moderate to high CHD risk (Framingham) and high-risk occupation (e.g., airline pilot)
• Appropriate, if high CHD risk (Framingham)

Risk Assessment With Prior Test Results, Asymptomatic OR Stable Symptoms, Normal Prior SPECT MPI Study
• Inappropriate, if normal initial RNI study and high CHD risk (Framingham) and annual SPECT MPI study
• Appropriate, if normal initial RNI study and high CHD risk (Framingham) and repeat SPECT MPI study after 2 years or greater

Risk Assessment With Prior Test Results, Asymptomatic OR Stable Symptoms, Abnormal Catheterization OR Prior SPECT MPI Study
• Inappropriate, if known CAD on catheterization OR prior SPECT MPI study in patients who have not had revascularization procedure and symptomatic OR stable symptoms and less than 1 year to evaluate worsening disease
• Appropriate, if known CAD on catheterization or prior SPECT MPI study and in patients who have not had revascularization procedure and greater than or equal to 2 years to evaluate worsening disease

Risk Assessment With Prior Test Results, Worsening Symptoms, Abnormal Catheterization OR Prior SPECT MPI Study
• Appropriate, if known CAD on catheterization OR prior SPECT MPI study

Risk Assessment With Prior Test Results, Asymptomatic, Abnormal Catheterization OR Prior SPECT MPI Study
• Inappropriate, if known CAD on catheterization OR prior SPECT MPI study in patients who have not had revascularization procedure and symptomatic OR stable symptoms and less than 1 year to evaluate worsening disease
• Appropriate, if known CAD on catheterization or prior SPECT MPI study and in patients who have not had revascularization procedure and greater than or equal to 2 years to evaluate worsening disease

Risk Assessment With Prior Test Results, Asymptomatic, CT Coronary Angiography
• Uncertain, if stenosis of unclear significance

Risk Assessment With Prior Test Results Asymptomatic, Prior Coronary Calcium Agatston Score
• Appropriate, if Agatston score greater than or equal to 400
• Inappropriate, if Agatston score less than 100

Risk Assessment With Prior Test Results, UA/NSTEMI, STEMI, or Chest Pain Syndrome, Coronary Angiogram
• Appropriate, if stenosis of unclear significance

Risk Assessment With Prior Test Results, Duke Treadmill Score
• Appropriate, if intermediate Duke treadmill score and Intermediate CHD risk (Framingham)

Risk Assessment: Preoperative Evaluation for Noncardiac Surgery, Low-Risk Surgery
• Inappropriate, if preoperative evaluation for noncardiac surgery risk assessment

• Inappropriate, if minor to intermediate perioperative risk predictor and normal exercise tolerance (greater than or equal to 4 METS)
• Appropriate, if intermediate perioperative risk predictor or poor exercise tolerance (less than 4 METS)

Risk Assessment: Preoperative Evaluation for Noncardiac Surgery, High-Risk Surgery
• Uncertain, if minor perioperative risk predictor an normal exercise tolerance (greater than or equal to 4 METS)
• Appropriate, if minor perioperative risk predictor and poor exercise tolerance (less than 4 METS)
• Inappropriate, if asymptomatic up to 1 year post normal catheterization, noninvasive test, or previous revascularization

Risk Assessment: Following Acute Coronary Syndrome STEMI—Hemodynamically Stable
• Appropriate, if Thrombolytic therapy administered and not planning to undergo catheterization

Risk Assessment: Following Acute Coronary Syndrome STEMI—Hemodynamically Unstable, Signs of Cardiogenic Shock, or Mechanical Complications
• Inappropriate, if Thrombolytic therapy administered

Risk Assessment: Following Acute Coronary Syndrome UA/NSTEMI—No Recurrent Ischemia or No Signs of HF
• Appropriate, if Not planning to undergo early catheterization
Risk Assessment: Following Acute Coronary Syndrome ACS—Asymptomatic Post Revascularization (PCI or CABG)
- Inappropriate, if routine evaluation prior to hospital discharge

Risk Assessment: Post-Revascularization (PCI or CABG), Symptomatic
- Appropriate, if evaluation of chest pain syndrome

Risk Assessment: Post-Revascularization (PCI or CABG), Asymptomatic
- Uncertain, if asymptomatic prior to previous revascularization and less than 5 years after CABG
- Appropriate, if asymptomatic prior to previous revascularization and greater than or equal to 5 years after CABG
- Appropriate, if symptomatic prior to previous revascularization and greater than or equal to 5 years after CABG
- Uncertain, if asymptomatic prior to previous revascularization and less than 2 years after PCI
- Uncertain, if symptomatic prior to previous revascularization and less than 2 years after PCI
- Uncertain, if symptomatic prior to previous revascularization and greater than or equal to 2 years after PCI
- Uncertain, if symptomatic prior to previous revascularization and greater than or equal to 2 years after PCI

Assessment of Viability/Ischemia, Ischemic Cardiomyopathy, Includes SPECT Imaging for Wall Motion and Ventricular Function)
- Appropriate, if known CAD on catheterization and patient eligible for revascularization

Evaluation of Ventricular Function, Evaluation of Left Ventricular Function
- Appropriate, if non-diagnostic echocardiogram

Evaluation of Ventricular Function, Use of Potentially Cardiotoxic Therapy (e.g., Doxorubicin)
- Appropriate, if baseline and serial measurements

**American Heart Association:** The role of noninvasive testing in the clinical evaluation of women with suspected CAD (Mieres, et al., 2005) notes that stress myocardial gated perfusion SPECT imaging performed with contemporary techniques has high diagnostic and prognostic accuracy in the evaluation of symptomatic women with an intermediate to high risk of CAD.

**Gastrointestinal - Literature Review**
Gastrointestinal scintigraphy is performed for numerous indications, including but not limited to:
demonstration of salivary gland function and tumors; detection of heterotopic functioning gastric mucosa; demonstration of the presence and site of acute gastrointestinal bleeding; verification of aspiration; evaluation and quantification of transit through and reflux into the esophagus; quantification of the rate of emptying of liquid and/or solid meals from the stomach; transit through the small and large intestine; Meckel’s diverticulum; assessment of peritoneovenous shunt patency; detection of congenital or acquired perforation of the pleuroperitoneal diaphragm; demonstration of the presence or absence of peritoneal loculations prior to intraperitoneal chemotherapy or radiopharmaceutical therapy.

Scintigraphy is used to assess motility disorders of the esophagus and in the investigation of gastrointestinal reflux disease. It is well established as the gold standard for the assessment of gastric emptying. Radionuclide studies of gastric emptying and motility are the most physiologic studies available for studying gastric motor function (ACR, 2005; SNM, 2004).

Scintigraphy for neuroendocrine tumors of the pancreas and bowel can be performed using radiolabelled somatostatin analogues and vasoactive intestinal peptide ($^{123}$I-vasoactive intestinal peptide [VIP]). The main advantages of scintigraphy are its ability to image the whole body and to detect tumors or their metastases as small as one centimeter in diameter, especially in areas not under clinical suspicion. These imaging techniques can also be used to monitor the effects of therapy. These small tumors can also be located at surgery using hand-held gamma probes (Grainger, et al., 2003).
Radionuclide imaging plays an important role in the localization and management of carcinoids, neuroendocrine neoplasms occurring most commonly within the gastrointestinal system. The ability of these tumors to concentrate $^{123}\text{I}$- or $^{131}\text{I}$-metaiodobenzyl-guanidine (MIBG) allows scintigraphy to be performed with a cumulative sensitivity of 71%. The most common midgut carcinoids (appendix and distal ileum) probably concentrate the radiolabelled MIBG more readily than those in the foregut and hindgut. The main use for $^{123}\text{I}$-MIBG scintigraphy is as a prelude to $^{131}\text{I}$-MIBG therapy, for which good palliative results have been obtained. $^{111}\text{In}$-pentetreotide has also been used to image these tumors, which has a higher sensitivity (86%) than MIBG. Scintigraphy with radiolabeled octreotide, a long-acting somatostatin analog, is useful in localizing both primary and metastatic carcinoid tumors, with a sensitivity of about 90% (Grainger, et al., 2003; Noble, 2001).

Radionuclide scintigraphy is useful for investigating suspected intestinal bleeding, for detecting Meckel's diverticulum, and in the assessment of inflammatory bowel disease. Radionuclide studies, either Tc-labeled red cells or sulphur colloid, may be valuable in the management of GI bleeding, usually as a complementary technique to arteriography. Radionuclide methods are very sensitive in detecting blood loss from the GI tract, but are less accurate than arteriography in localizing the site of bleeding. In many canters, scintigraphy is used to establish whether or not active hemorrhage is occurring before submitting the patient to arteriography in order to define the bleeding site precisely. The relative roles of the two methods in the management of bleeding depend very much on the facilities and expertise locally available. Radionuclide scintigraphy, using Tc-99m pertechnetate, is a well-established technique for identifying a Meckel's diverticulum that contains gastric mucosa, as this agent is concentrated in the mucus-secreting cells and the parietal cells of the gastric mucosa in both the stomach and the diverticulum. $^{111}\text{In}$-labeled leukocytes can be used to image inflammatory bowel disease (Grainger, et al., 2003).

Radionuclide scans may be used prior to angiography to determine which patients are bleeding sufficiently to make a positive angiographic result more likely. Bleeding at rates as low as 0.1 ml/min can be detected by using such radionuclide scans in the experimental setting. Tc-99m pertechnetate scan (i.e., Meckel scan) selectively tags gastric mucosa; it is used most often for unexplained bleeding in infants and young adults. Tc-99m sulfur colloid scan is very sensitive in detecting lesions with low bleeding rates. Tc-99m-labeled RBC scan is useful for intermittent bleeding because the patient can be monitored for gastrointestinal bleeding for 24 to 48 hours. Given its lack of side effects and non invasive nature, it is also a reasonable choice in patients who are initially clinically too unstable for a more invasive procedure (Ferri, et al., 2004).

Gastrointestinal - Professional Societies/Organizations

American Gastroenterological Association: In the diagnosis and treatment of gastroparesis, gastric emptying scintigraphy of a radiolabeled solid meal is the best accepted method to test for delayed gastric emptying (Parkman, et al., 2004).

American College of Gastroenterology: In diverticular hemorrhage, urgent flexible sigmoidoscopy is an appropriate initial approach. If no obvious etiology is found, then further evaluation with noninvasive (nuclear scintigraphy) or invasive techniques (angiography, colonoscopy) can be undertaken in an attempt to localize and/or treat the bleeding source (Stollman, et al., 1999).

In the diagnosis and management of achalasia, objective tests to better assess improvement after pneumatic dilation include manometry (lower esophageal sphincter [LES] pressure, 10 mm Hg), esophageal scintigraphy, and the timed barium esophagram. The adjunctive use of these tests may help to improve the long-term success of pneumatic dilation, but this premise is still speculative (Vaezi, et al., 1999).

Hepatobiliary - Literature Review

Hepatobiliary scintigraphy is performed for numerous indications, including but not limited to: evaluation of acute cholecystitis; evaluation of common bile duct obstruction; evaluation of right upper quadrant pain or mass; detection of enterogastric reflux; postoperative assessment of biliary enteric bypass; evaluation of hepatic transplant function; evaluation of neonatal hyperbilirubinemia (biliary atresia vs. neonatal...
hepatitis “syndrome”); and assessment of chronic biliary tract disorders. Hepatobiliary scintigraphy evaluates hepatocellular function and patency of the biliary system by tracing the production and flow of bile from the liver through the biliary system into the small intestine (ACR, 2003; SNM, 2001).

Radionuclide imaging of the liver is commonly performed using Tc-99m sulphur colloid or albumin colloid, which target the reticulo-endothelial system. Liver scintigraphy lacks anatomical specificity but provides a global view of the liver and is unaffected by bowel gas and the majority of surgical clips and implants. It is infrequently used as a primary diagnostic investigation but can help to further characterize known lesions when CT and MRI are not available.

Scintigraphy using Tc-99m-labelled derivatives of iminodiacetic acid (HIDA and PIPIDA) is a simple and highly accurate method of diagnosing acute cholecystitis. False-positives can occur in alcoholic liver disease and in patients receiving parenteral nutrition (Grainger, et al., 2003).

**Hepatosplenic - Literature Review**

Hepatosplenic scintigraphy (e.g., liver/spleen imaging, liver blood pool imaging, hepatic artery perfusion) is performed for numerous indications, including but not limited to: assessing the size, shape, and position of the liver and spleen; detecting, measuring, and monitoring of masses of either organ; differentiating hepatic hemangiomas and focal nodular hyperplasia from other liver lesions; measuring and evaluating hepatic function in cases of acute or chronic liver disease; confirming the patency and arterial distribution of hepatic arterial perfusion catheters; identifying functional splenic tissue; and evaluating suspected functional asplenia (ACR, 2005; SNM, 2003).

**Infections and Inflammation - Literature Review**

Infection or inflammation scintigraphy is performed for numerous indications, including but not limited to: fevers of unknown origin (FUO); disk space and joint space infections; potential infections in immunocompromised patients; tuberculosis; sarcoidosis; pulmonary inflammation from therapeutic or environmental agents; inflammatory bowel disease; osteomyelitis; vascular infections; and evaluation of a painful prosthesis (ACR, 2004; SNM, 2004). Bone scanning does not detect the presence of infection but instead reflects inflammatory changes or the reaction of bone to the infection (Canale, 2003).

**Infections and Inflammation - Professional Societies/Organizations**

Gallium ($^{67}$Ga) whole body scintigraphy may be done to localize source of fever in patients with FUO. $^{67}$Ga scintigraphy may be performed to: detect pulmonary and mediastinal inflammation/infection, especially in the immunocompromised patient; evaluate and follow up active lymphocytic or granulomatous inflammatory processes (e.g., sarcoidosis or tuberculosis); diagnose osteomyelitis and/or disk space infection ($^{67}$Ga is preferred over labeled leukocytes for disk space infection and vertebral osteomyelitis); diagnose and follow up medical treatment of retroperitoneal fibrosis; evaluate and follow up drug-induced pulmonary toxicity (e.g., bleomycin, amiodarone).

$^{111}$In-leukocyte scintigraphy may be performed to: detect sites of infection/inflammation in patients with FUO; localize an unknown source of sepsis and to detect additional site(s) of infection in patients with persistent or recurrent fever and a known infection site; survey for site(s) of abscess or infection in a febrile postoperative patient without localizing signs or symptoms (fluid collections, ileus, bowel gas, fluid, and/or healing wounds reduce the specificity of CT and ultrasound); detect site(s) and extent of inflammatory bowel disease (Tc-99m-labeled leukocytes may be preferable for this indication); detect and follow up osteomyelitis primarily when there is increased bone remodeling secondary to joint prostheses, nonunited fractures, or sites of metallic hardware from prior bone surgery; detect osteomyelitis in diabetic patients when degenerative or traumatic changes, neuropathic osteoarthropathy, or prior osteomyelitis have caused increased bone remodeling; detect osteomyelitis involving the skull in postoperative patients and for follow-up of therapy; and detect mycotic aneurysms, vascular graft infections, and shunt infections.

Tc-99m HMPAO-labeled leukocyte scintigraphy may be performed to: detect suspected sites of acute inflammation/infection in the febrile patient with or without localizing signs or symptoms; detect and determine the extent of inflammatory or ischemic bowel disease (may be more sensitive than leukocyte scintigraphy for detection of disease, particularly involving the small bowel). $^{111}$In-leukocytes are preferred for quantitative assessment; and detect and follow up musculoskeletal infection (e.g., septic
arthritis, osteomyelitis) (may be more sensitive for detection of acute than chronic osteomyelitis, combined $^{111}$In-white blood cell (WBC)/$^{99m}$Tc-diphosphonate bone and/or $^{111}$In-WBC/$^{99m}$Tc sulfur colloid marrow scans are preferred in difficult cases of osteomyelitis at sites with existing bone alteration and/or adjacent soft-tissue infection) (SNM, 2004).

**Lung - Literature Review**

Pulmonary scintigraphy is performed for numerous indications, including but not limited to: assessing the probability of acute or chronic pulmonary thromboembolic disease; establishing the presence of chronic, unresolved pulmonary emboli; quantifying of differential pulmonary function; evaluating lung transplants; evaluating the effects of congenital heart/lung disease; confirming the presence of bronchopleural fistulae; and evaluating the effects of chronic pulmonary parenchymal disorders such as cystic fibrosis (ACR, 2004; SNM, 2004).

Perfusion scintigraphy may be useful to identify target areas of emphysema for resection during lung volume reduction surgery (LVRS). In vivo, computed tomography is the most accurate technique for identifying and quantifying emphysema. Perfusion scintigraphy may be used to identify focal heterogeneous emphysema. CT was a better predictor of improved function after LVRS than perfusion scintigraphy; in general, however, neither technology has emerged as the dominant technique in patient selection and surgical planning. In emphysema patients, both planar and SPECT perfusion scintigraphy can be used to provide qualitative and/or quantitative assessment of differential pulmonary parenchymal perfusion, extrapolating that areas of absent perfusion represent emphysema. Ventilation scintigraphy is not useful (Grainger, et al., 2003).

Radioactive gallium scanning has been used to evaluate patients with interstitial lung disease. Its role also remains somewhat controversial because of its non-specificity; varied types of pulmonary inflammation as well as neoplasms can produce a positive result. Gallium scanning has been used to follow the course of disease during treatment but has been disappointing in predicting responsiveness to corticosteroid or immunosuppressive therapy; only 10% to 30% of patients with increased uptake may respond to therapy. Favorable responses to therapy have been noted even when the gallium scans are normal. Gallium scanning may be helpful in planning a biopsy procedure by identifying areas of active inflammation and thus increasing the probability of a positive result (Noble, 2001).

Perfusion lung scanning has been in use for 30 years and is a sensitive but nonspecific method for evaluating pulmonary perfusion. Macroaggregated albumin labeled with Tc-99m is injected intravenously, and anterior, posterior, lateral, and oblique views of the chest are taken. Ventilation scanning is often performed after the perfusion scan to increase its specificity. Xenon133 is inhaled for several minutes to fill all areas of the lung. The patient then breathes ambient air, and the washout of the isotope is studied. With normal ventilation, the lungs clear rapidly and symmetrically. Areas of retained radioactivity indicate abnormal ventilation. Areas of normal ventilation with abnormal perfusion (mismatch) are very suggestive of PE (Noble, 2001).

**Multiple Myeloma - Literature Review**

Tc-99m bone scanning is inferior to conventional radiography and should not be routinely used, as abnormalities on bone scan only correlate with sites of blastic change and thus lytic disease can be missed (Abeloff, et al., 2004). Bone scintigraphy has no place in the routine investigation of myeloma, as CT is more sensitive (Smith, et al., 2006).

**Parathyroid - Literature Review**

Parathyroid scintigraphy is performed for numerous indications, including but not limited to: are prior to surgery to facilitate identification and removal of abnormal parathyroid tissue; and subsequent to surgery in patients with persistent or recurrent hyperparathyroidism to detect aberrant or ectopic hyperplastic or neoplastic glands (ACR, 2004; SNM, 2004). Preoperative technetium Tc-99m sestamibi scanning can accurately localize 80% to 90% of the single adenomas that account for 75% to 85% of cases. Sestamibi scanning also can identify the occasional mediastinal adenoma and thereby direct the surgeon away from neck exploration. On the other hand, because the sensitivity of sestamibi scanning ranges from 75% to 90% and the technique is least reliable in the presence of multiglandular disease (hyperplasia or double adenomas), the test may falsely localize an adenoma or miss the presence of bilateral disease in 10% to 20% of patients (Larsen, et al., 2003).
**Parathyroid - Professional Societies/Organizations**

**American Association of Clinical Endocrinologists (AACE):** In primary hyperparathyroidism (PHPT), ultrasonography or SPECT sestamibi scanning (or both) of the parathyroid glands should be used for operative planning. Specifically, if preoperative ultrasonography or sestamibi scanning localizes an adenoma, this information facilitates a focused or minimally invasive surgical approach. Although some surgeons do not obtain preoperative imaging for patients at high risk of hyperplasia, preoperative ultrasonography or sestamibi scanning can be helpful in localizing an ectopic parathyroid gland (AACE, 2005).

**SNM:** Parathyroid scintigraphy may be performed to localize hyperfunctioning parathyroid tissue (adenomas or hyperplasia) in primary hyperparathyroidism or in patients with persistent or recurrent disease (usually adenomas). Dual-phase or double-phase imaging refers to utilizing Tc-99m sestamibi and acquiring early and delayed images. Dual-isotope or subtraction studies refer to protocols using two different radiopharmaceuticals for imaging acquisition (SNM, 2004).

**Renal / Urinary - Literature Review**

Renal or urinary scintigraphy is performed for numerous indications, including but not limited to: detection, evaluation, and quantification of possible urinary tract obstruction; detection and evaluation of renovascular disease; detection of pyelonephritis and parenchymal scarring; detection and evaluation of functional and anatomic abnormalities of transplanted kidneys; qualitative measurement of renal function; detection of congenital and acquired anatomic renal abnormalities; quantification of certain parameters of renal function, such as effective renal plasma flow, excretory index, glomerular filtration rate, and differential renal function; renal cortical scintigraphy for the detection of the cortical defects of acute pyelonephritis and scarring related to chronic pyelonephritis; ad radionuclide cystography for the detection and evaluation of vesicoureteral reflux and quantification of postvoid bladder residual (ACR, 2003, 2005; SNM, 2003). Radionuclide imaging may be used in a wide variety of ways for studying the function of the renal tract; clearance techniques; dynamic renal imaging; renal transplant; vesico-ureteric reflux; residual bladder volume; captopril scan. For urinary obstruction, radionuclide techniques provide important information on urine transport and renal function in patients with known or possible obstruction. Radionuclide techniques offer more functional information than excretory urography, US, or CT, but cannot match them with respect to morphological detail. Quantitative radionuclide scans offer the best noninvasive assessment of individual renal function after release of obstruction (Grainger, et al., 2001).

SPECT using Tc-99m dimercaptosuccinate (Tc-99m DMSA) is slightly more sensitive than CT for identifying areas of inflammation within the kidney in pyelonephritis, which can be advantageous if the initial diagnosis is in question. However, it cannot distinguish between frank abscesses and inflamed but viable tissue, and so it is of little help in evaluating the patient who fails to respond to the therapy (Cohen, et al., 2004). Gallium scintigraphy has been used to determine the presence of interstitial inflammation in drug-induced allergic interstitial nephritis (Noble, 2001).

In urinary stone disease, renal radionuclide studies provide rapid and safe information about total and differential renal function. These tests are specifically advantageous because the radionuclide evaluation is not invasive, requires no bowel preparation or specific preoperative preparation, subjects the patient to only minimal radiation exposure, and is apparently free of allergic complications (Noble, 2001).

**Renal / Urinary - Professional Societies/Organizations**

**American Urological Association (AUA):** In a child with vesicoureteral reflux (VUR), the upper urinary tract can be evaluated by one of several techniques, including renal cortical scintigraphy (renal scan), excretory urography (intravenous pyelography [IVP]), and renal ultrasound. Radiopharmaceuticals used for renal scanning include dimercapto succinic acid (DMSA), glucoheptonate, and mercaptoacetyltriglycine (MAG-3). Following an episode of pyelonephritis, renal scarring usually is apparent on scintigraphy within three months, but may not be apparent on an IVP or sonography until one-two years later (AUA, 1997).
In the AUA Prostate Cancer Guideline (1995), it notes that a staging radionuclide bone scan may no longer be necessary for the patient with newly diagnosed, untreated prostate cancer who has no skeletal symptoms and a serum PSA concentration of 10 ng/ml or less.

**Scrotum - Literature Review**
Scrotal scintigraphy is performed for differentiation of specific causes of acute and subacute scrotal pain, especially testicular torsion and epididymitis/orchitis. The procedure is not indicated in evaluating cryptorchidism, tumors, or chronic inflammation (ACR, 2004).

**Thyroid - Literature Review**
Thyroid scintigraphy is performed for numerous indications, including but not limited to: detection of focal and/or global abnormalities of thyroid anatomy, correlation of anatomy with function, detection of aberrant or metastatic functioning thyroid tissue or residual normal tissue after therapy, thyroid uptake in hyperthyroidism, and whole-body imaging for thyroid carcinoma (ACR, 2004; SNM, 1999).

Radioisotope imaging with radioiodine (\(^{123}\)I) is commonly utilized to determine the overall activity of the gland in patients with thyrotoxicosis (24-hour radioactive iodine uptake [RAIU]) as well as to provide information regarding the function of parts of the gland, such as nodules. Radioisotope imaging with Tc-99m pertechnetate provides information on the regional function within the gland but is less informative regarding the overall function of the gland. Whereas RAIU distinguishes etiology based on iodine uptake, thyroid radionuclide imaging can distinguish different forms of goiter. A thyroid scan is generally performed when the thyroid gland appears to be nodular on physical examination to establish the diagnosis of toxic nodular or multinodular goiter. In addition, a thyroid scan may be ordered in a patient with Graves' disease when a thyroid nodule is palpated so as to rule out a coexistent cold nodule (Noble, 2001).

**Thyroid - Professional Societies/Organizations**

**American Association of Clinical Endocrinologists (AACE):** Thyroid scan, with either \(^{123}\)I (preferably) or Tc-99m pertechnetate, is not a thyroid function test but is done to help determine the cause of the hyperthyroidism. The scan may also be useful in assessing the functional status of any palpable thyroid irregularities or nodules associated with a toxic goiter (AACE, amended 2006).

**Tumor - Literature Review**
Tumor scintigraphy is performed for numerous indications, including but not limited to: detection of certain primary, metastatic, and recurrent tumors, evaluation of abnormal imaging and nonimaging findings in patients with a history of certain tumors, and reassessment of patients for residual tumor burden after therapy. Specific clinical applications depend on the specific radiopharmaceutical:

- \(^{67}\)Gallium citrate (e.g., Hodgkin's lymphoma, non-Hodgkin's lymphoma, melanoma, lung cancer, and hepatoma, sarcoma, testicular tumors, multiple myeloma, head and neck tumors)
- radiiodinated MIBG (i.e., neuroendocrine tumors)
- radiolabeled monoclonal antibodies (e.g., OncoScint®, ProstaScint®, and CEA-SCAN®)
- \(^{111}\)In Octreotide (Octreoscan®) (e.g., medullary thyroid carcinoma, gastrinoma, pheochromocytoma, neuroblastoma, and carcinoid)
- NeoTect (Tc-99m Detreotide) (i.e., noninvasive characterization of pulmonary masses)
- Thallium-201 (Thallous Chloride) (e.g., glioblastoma, osteosarcoma, lymphoma, thyroid carcinoma, breast tumors)
- Tc-99m sestamibi (e.g., Miraluma®) (ACR, 2005; SNM, 2001)

The majority of brain tumor investigation imaging has been with PET. SPECT has a more limited role in the evaluation of brain tumors. SPECT has been used to distinguish between low-grade and high-grade gliomas and radiation change. Tumors expressing somatostatin receptors, such as certain pituitary adenomas and meningiomas, can be identified with \(^{111}\)In-octreotide scintigraphy. Radionuclide studies are rarely used in the investigation of meningiomas, but when other imaging findings are atypical, somatostatin receptor scintigraphy with \(^{111}\)In-octreotide can confirm a diagnosis of meningioma and can detect residual or recurrent tumor postoperatively. Radionuclide studies, although rarely used, may provide useful information in selected cases. Some pituitary macroadenomas express somatostatin
receptors and $^{111}$In-octreotide uptake has been demonstrated reliably in growth hormone-secreting adenomas and in some prolactin adenomas. Trans-sphenoidal surgery for macroadenomas may result in incomplete tumor resection due to involvement of adjacent structures such as the cavernous sinus, and $^{111}$In-octreotide scintigraphy is useful in distinguishing residual or recurrent tumor from postoperative scarring. $^{111}$In octreotide scintigraphy can also identify which patients with pituitary macroadenoma may respond to octreotide therapy (Grainger, et al. 2003; Goetz, 2003).

Tumors of the pituitary gland are best diagnosed with MRI because it has better resolution than other radiologic modalities for identifying soft tissue changes. SPECT has a sensitivity of about 1 cm and can detect normal pituitary tissue receptor expression. Because most adenomas and normal tissue are identified by this technique, its utility is limited for tumor detection, but it may be helpful for imaging ectopic ACTH-secreting tumors (Larsen, et al., 2003).

Extraadrenal pheochromocytomas or very small adrenal tumors are harder to localize and may require $^{131}$I-MIBG scanning. This isotope, although expensive, is specific for catecholamine-producing tissue and has 80% sensitivity and over 95% specificity for localization of malignant pheochromocytomas. $^{111}$In-pentetreotide (Octreoscan) is reported to be of similar sensitivity. Those who are found to have bilateral adrenal tumors should be screened for other manifestations of the multiple endocrine neoplasia (MEN) syndromes (Noble, 2001).

Tumor - Professional Societies/Organizations

National Comprehensive Cancer Network (NCCN): NCCN Clinical Practice Guidelines in Oncology™ state the following:

Bladder Cancer:
Bone scan if alkaline phosphatase elevated or symptoms.

Bone Cancer:
Osteosarcoma: A technetium bone scan, while uniformly abnormal at the lesion, may be useful to identify additional synchronous lesions. Perhaps the best single study for osteosarcoma, MRI provides excellent soft-tissue contrast.
Osteosarcoma Surveillance: Examination should include a complete physical, chest imaging, and plain film of the extremity. Chest CT should be done if the plain chest radiograph becomes abnormal. Bone scan may also be considered in this case.
Ewing's sarcoma family of tumors: If ESFT is suspected as a diagnosis, the patient should undergo complete staging prior to biopsy. This should include CT of the chest, plain radiographs of the primary site, as well as a CT or MRI of the entire involved bone or area. A technetium bone scan should also be performed. Post-chemotherapy, bone scan is considered optional.

Breast Cancer: (See CIGNA's Scintimammography Coverage Position)
Stage I, II, IIB, or T3N1M0 Invasive Breast Cancer: Radionuclide bone scanning and abdominal imaging with CT, ultrasound, or MRI are indicated for patients with T3N1M0 disease, if the patient has symptoms related to bone or abdomen, or an elevated alkaline phosphatase. In the remaining patients, bone scan and abdominal imaging are considered optional.
Stage III Invasive Breast Cancer: The workup includes history and physical exam, a complete blood cell count, platelet count, a bone scan, chest imaging, pathology review, pre-chemotherapy determination of tumor ER/PR receptor status and HER-2 status, diagnostic bilateral mammogram and breast ultrasound as clinically warranted, and an abdominal CT, ultrasound, or MRI, even in the absence of symptoms, liver enzyme abnormalities, or abnormal alkaline phosphatase.

CNS Cancers:
Neoplastic Meningitis: CSF flow scans are easily performed in most nuclear medicine departments. $^{111}$In-DTPA is administered into the subcutaneous reservoir and ventricular catheter, and imaging of the brain and spine is performed immediately after injection.

Kidney Cancer:
“Bone scan if indicated” listed under suspicious mass workup.
Neuroendocrine Tumors:
Octreoscan indicated numerous times within algorithm.

Non-Hodgkin’s Lymphoma:
PET scan (preferred) or $^{67}$Gallium scan (planar and SPECT) double dose with delayed images as an alternative if PET not available.

Prostate Cancer:
Bone scan listed several times throughout algorithm.

Small Cell Lung Cancer:
Bone scan listed several times throughout algorithm.

Testicular Cancer:
Bone scan if clinically indicated.

Thyroid Cancer:
Whole-body $^{131}$I scans are often performed after surgery to assess the completeness of thyroidectomy and the presence of residual disease.

American College of Chest Physicians: For noninvasive staging of non-small cell lung cancer, experience with SPECT imaging for lung cancer is still very limited, and thus SPECT scanning should not be considered as an alternative to FDG-PET scanning (Silvestri, et al., 2003).

American Society of Clinical Oncology (ASCO): Guideline Recommendations for Sentinel Lymph Node Biopsy in Early-Stage Breast Cancer notes that lymphoscintigraphic imaging can be useful in demonstrating unexpected draining nodes, especially in the internal mammary region and may guide probe-based surgery. The clinical significance of such findings may include additional invasive procedures to determine the nodal histology or the use of external beam irradiation of internal mammary nodes—depending on the therapeutic intent. It is clear that lymphoscintigraphy is not a substitute for probe-based surgery but is adjunctive. Lymphoscintigraphy is, however, a routine part of the practice pattern in many centers where it precedes and can direct the performance of the radionuclide guided probe-based sentinel node surgery (Lyman, et al., 2005).

SPECT/CT Imaging
SPECT and CT are proven diagnostic procedures. The first SPECT/CT system combined a dual-head gamma camera and an integrated x-ray transmission system mounted on the same gantry. More recently, additional integrated SPECT/CT devices have become available, including systems combining a state-of-the-art multi-head gamma camera and multi-detector CT scanner side by side with a common imaging table. Combined SPECT/CT devices provide both the functional information from SPECT and the anatomic information from CT in a single examination. Some studies have demonstrated that the information obtained by SPECT/CT is more accurate in evaluating patients than that obtained from either SPECT or CT alone. Although techniques for registration and fusion of images obtained from separate SPECT and CT scanners have been available for several years, the advantages of having SPECT and CT integrated into a single device have resulted in the development of this technology (SNM, 2006).

Consistent with trends in PET/CT systems, hybrid SPECT systems have evolved, combining SPECT and CT systems. In nuclear cardiology, SPECT components are typically large field of view variable angle dual detector systems. These combined systems, in practice, demonstrate a range of capability and integration. CT components range from non-diagnostic units suitable for use in anatomical localization and attenuation correction to 16 slice systems capable of computed tomography angiography. The SPECT detectors in SPECT/CT systems do not differ in any significant way from those of stand-alone SPECT systems. These systems may be viewed from a protocol perspective as stand-alone systems where an emission study is followed or preceded by a CT scan for attenuation correction. Depending upon the number of CT slices acquired, the CT scanner may be used, as with stand-alone CT scanners, for CTA and calcium scoring. The CT and SPECT components may then be analyzed independently or in three dimensional image registrations, depending on the type of study (ASNC, 2006).
Society of Nuclear Medicine (SNM): SNM Procedure Guideline for SPECT/CT Imaging (May, 2006) states that indications for SPECT/CT include but are not limited to imaging of the following:

- tumors
- thyroid disorders
- parathyroid disorders
- skeleton disorders
- inflammation or infection
- lymphatic system
- heart disorders
- brain disorders
- other organs

Summary
Evidence in the published peer-reviewed scientific literature, textbooks, and current clinical practice demonstrate that nuclear imaging including single-photon emission computed tomography (SPECT) is a proven and well-established imaging modality. Specific clinical applications depend on the specific radiopharmaceutical. Nuclear imaging including SPECT may be utilized when other imaging studies are inconclusive or contraindicated. Along with oncologic and cardiac indications, nuclear imaging with SPECT has proven helpful in bone, brain, gastrointestinal, lung, endocrine and renal and urinary disorders. SPECT has proven helpful in patients with suspected or known infection and inflammatory processes.

The American Society of Nuclear Cardiology (ASNC) Imaging Guidelines for Nuclear Cardiology Procedures (2006) and the American College of Cardiology Foundation (ACCF)/ASNC Appropriateness Criteria for SPECT Myocardial Perfusion Imaging (2005) were the primary sources for CIGNA’s cardiac nuclear imaging coverage determinations.

Nuclear imaging has not been proven to be of value in chronic fatigue syndrome, multiple myeloma, neuropsychiatric disorders, scrotal tumors, chronic scrotal inflammation or cryptorchidism, or for screening for coronary artery disease.

NOTE: See CIGNA’s Monoclonal Antibody (MAb) Imaging or Radioimmunoscintigraphy Coverage Position and CIGNA’s Scintimammography Coverage Position.

Coding/Billing Information

Note: This list of codes may not be all-inclusive.

Covered when medically necessary:

<table>
<thead>
<tr>
<th>CPT® Codes</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>78000</td>
<td>Thyroid uptake; single determination</td>
</tr>
<tr>
<td>78001</td>
<td>Thyroid uptake; multiple determinations</td>
</tr>
<tr>
<td>78003</td>
<td>Thyroid uptake; stimulation, suppression or discharge (not including initial uptake studies)</td>
</tr>
<tr>
<td>78006</td>
<td>Thyroid imaging, with uptake; single determination</td>
</tr>
<tr>
<td>78007</td>
<td>Thyroid imaging, with uptake; multiple determinations</td>
</tr>
<tr>
<td>78010</td>
<td>Thyroid imaging; only</td>
</tr>
<tr>
<td>78011</td>
<td>Thyroid imaging; with vascular flow</td>
</tr>
<tr>
<td>78015</td>
<td>Thyroid carcinoma metastases imaging; limited area (e.g., neck and chest only)</td>
</tr>
<tr>
<td>78016</td>
<td>Thyroid carcinoma metastases imaging; with additional studies (e.g., urinary recovery)</td>
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<tr>
<td>78018</td>
<td>Thyroid carcinoma metastases imaging; whole body</td>
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<td>78020</td>
<td>Thyroid carcinoma metastases uptake</td>
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<td>78070</td>
<td>Parathyroid imaging</td>
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<td>78075</td>
<td>Adrenal imaging, cortex and/or medulla</td>
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<tr>
<td>78102</td>
<td>Bone marrow imaging; limited area</td>
</tr>
<tr>
<td>78103</td>
<td>Bone marrow imaging; multiple areas</td>
</tr>
<tr>
<td>78104</td>
<td>Bone marrow imaging; whole body</td>
</tr>
<tr>
<td>78110</td>
<td>Plasma volume, radiopharmaceutical volume-dilution technique (separate procedure); single sampling</td>
</tr>
<tr>
<td>78111</td>
<td>Plasma volume, radiopharmaceutical volume-dilution technique (separate procedure); multiple samplings</td>
</tr>
<tr>
<td>78120</td>
<td>Red cell volume determination (separate procedure); single sampling</td>
</tr>
<tr>
<td>78121</td>
<td>Red cell volume determination (separate procedure); multiple samplings</td>
</tr>
<tr>
<td>78122</td>
<td>Whole blood volume determination, including separate measurement of plasma volume and red cell volume (radiopharmaceutical volume-dilution technique)</td>
</tr>
<tr>
<td>78130</td>
<td>Red cell survival study;</td>
</tr>
<tr>
<td>78135</td>
<td>Red cell survival study; differential organ/tissue kinetics, (e.g., splenic and/or hepatic sequestration)</td>
</tr>
<tr>
<td>78140</td>
<td>Labeled red cell sequestration, differential organ/tissue, (e.g., splenic and/or hepatic)</td>
</tr>
<tr>
<td>78185</td>
<td>Spleen imaging only, with or without vascular flow</td>
</tr>
<tr>
<td>78190</td>
<td>Kinetics, study of platelet survival, with or without differential organ/tissue localization</td>
</tr>
<tr>
<td>78191</td>
<td>Platelet survival study</td>
</tr>
<tr>
<td>78195</td>
<td>Lymphatics and lymph nodes imaging</td>
</tr>
<tr>
<td>78199</td>
<td>Unlisted hematopoietic, reticuloendothelial and lymphatic procedure, diagnostic nuclear medicine</td>
</tr>
<tr>
<td>78201</td>
<td>Liver imaging; static only</td>
</tr>
<tr>
<td>78202</td>
<td>Liver imaging; with vascular flow</td>
</tr>
<tr>
<td>78205</td>
<td>Liver imaging (SPECT)</td>
</tr>
<tr>
<td>78206</td>
<td>Liver imaging (SPECT); with vascular flow</td>
</tr>
<tr>
<td>78216</td>
<td>Liver and spleen imaging; with vascular flow</td>
</tr>
<tr>
<td>78220</td>
<td>Liver function study with hepatobiliary agents, with serial images</td>
</tr>
<tr>
<td>78230</td>
<td>Hepatobiliary ductal system imaging, including gallbladder, with or without pharmacologic intervention, with or without quantitative measurement of gallbladder function</td>
</tr>
<tr>
<td>78231</td>
<td>Salivary gland imaging; with serial images</td>
</tr>
<tr>
<td>78232</td>
<td>Salivary gland function study</td>
</tr>
<tr>
<td>78258</td>
<td>Esophageal motility</td>
</tr>
<tr>
<td>78261</td>
<td>Gastric mucosa imaging</td>
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<tr>
<td>78262</td>
<td>Gastroesophageal reflux study</td>
</tr>
<tr>
<td>78264</td>
<td>Gastric emptying study</td>
</tr>
<tr>
<td>78270</td>
<td>Vitamin B-12 absorption study (e.g., Schilling test); without intrinsic factor</td>
</tr>
<tr>
<td>78271</td>
<td>Vitamin B-12 absorption study (e.g., Schilling test); with intrinsic factor</td>
</tr>
<tr>
<td>78272</td>
<td>Vitamin B-12 absorption studies combined, with and without intrinsic factor</td>
</tr>
<tr>
<td>78278</td>
<td>Acute gastrointestinal blood loss imaging</td>
</tr>
<tr>
<td>78282</td>
<td>Gastrointestinal protein loss</td>
</tr>
<tr>
<td>78290</td>
<td>Intestine imaging (e.g., ectopic gastric mucosa, Meckel's localization, volvulus)</td>
</tr>
<tr>
<td>78291</td>
<td>Peritoneal-venous shunt patency test</td>
</tr>
<tr>
<td>78300</td>
<td>Bone and/or joint imaging; limited area</td>
</tr>
<tr>
<td>78305</td>
<td>Bone and/or joint imaging; multiple areas</td>
</tr>
<tr>
<td>78306</td>
<td>Bone and/or joint imaging; whole body</td>
</tr>
<tr>
<td>78315</td>
<td>Bone and/or joint imaging; three phase study</td>
</tr>
<tr>
<td>78320</td>
<td>Bone and/or joint imaging; tomographic (SPECT)</td>
</tr>
<tr>
<td>78414</td>
<td>Determination of central c-v hemodynamics (non-imaging) (e.g., ejection fraction with probe technique) with or without pharmacologic intervention or exercise, single or multiple determinations</td>
</tr>
<tr>
<td>78428</td>
<td>Cardiac shunt detection</td>
</tr>
<tr>
<td>78445</td>
<td>Non-cardiac vascular flow imaging (i.e., angiography, venography)</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>78456</td>
<td>Acute venous thrombosis imaging, peptide</td>
</tr>
<tr>
<td>78457</td>
<td>Venous thrombosis imaging, venogram; unilateral</td>
</tr>
<tr>
<td>78458</td>
<td>Venous thrombosis imaging, venogram; bilateral</td>
</tr>
<tr>
<td>78460</td>
<td>Myocardial perfusion imaging; (planar) single study, at rest or stress (exercise and/or pharmacologic), with or without quantification</td>
</tr>
<tr>
<td>78461</td>
<td>Myocardial perfusion imaging; multiple studies, (planar) at rest and/or stress (exercise and/or pharmacologic), and redistribution and/or rest injection, with or without quantification</td>
</tr>
<tr>
<td>78464</td>
<td>Myocardial perfusion imaging; tomographic (SPECT), single study (including attenuation correction when performed), at rest or stress (exercise and/or pharmacologic), with or without quantification</td>
</tr>
<tr>
<td>78465</td>
<td>Myocardial perfusion imaging; tomographic (SPECT), multiple studies, (including attenuation correction when performed), at rest and/or stress (exercise and/or pharmacologic) and redistribution and/or rest injection, with or without quantification</td>
</tr>
<tr>
<td>78466</td>
<td>Myocardial imaging, infarct avid, planar; qualitative or quantitative</td>
</tr>
<tr>
<td>78468</td>
<td>Myocardial imaging, infarct avid, planar; with ejection fraction by first pass technique</td>
</tr>
<tr>
<td>78469</td>
<td>Myocardial imaging, infarct avid, planar; tomographic SPECT with or without quantification</td>
</tr>
<tr>
<td>78472</td>
<td>Cardiac blood pool imaging, gated equilibrium; planar, single study at rest or stress (exercise and/or pharmacologic), wall motion study plus ejection fraction, with or without additional quantitative processing</td>
</tr>
<tr>
<td>78473</td>
<td>Cardiac blood pool imaging, gated equilibrium; multiple studies, wall motion study plus ejection fraction, at rest and stress (exercise and/or pharmacologic), with or without additional quantification</td>
</tr>
<tr>
<td>78478</td>
<td>Myocardial perfusion study with wall motion, qualitative or quantitative study (List separately in addition to code for primary procedure)</td>
</tr>
<tr>
<td>78480</td>
<td>Myocardial perfusion study with ejection fraction (List separately in addition to code for primary procedure)</td>
</tr>
<tr>
<td>78481</td>
<td>Cardiac blood pool imaging, (planar), first pass technique; single study, at rest or with stress (exercise and/or pharmacologic), wall motion study plus ejection fraction, with or without quantification</td>
</tr>
<tr>
<td>78483</td>
<td>Cardiac blood pool imaging, (planar), first pass technique; multiple studies, at rest and with stress (exercise and/or pharmacologic), wall motion study plus ejection fraction, with or without quantification</td>
</tr>
<tr>
<td>78494</td>
<td>Cardiac blood pool imaging, gated equilibrium, SPECT, at rest, wall motion study plus ejection fraction, with or without quantitative processing</td>
</tr>
<tr>
<td>78496</td>
<td>Cardiac blood pool imaging, gated equilibrium, single study, at rest, with right ventricular ejection fraction by first pass technique (List separately in addition to code for primary procedure)</td>
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<tr>
<td>78580</td>
<td>Pulmonary perfusion imaging, particulate</td>
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<tr>
<td>78584</td>
<td>Pulmonary perfusion imaging, particulate, with ventilation; single breath</td>
</tr>
<tr>
<td>78585</td>
<td>Pulmonary perfusion imaging, particulate, with ventilation; rebreathing and washout, with or without single breath</td>
</tr>
<tr>
<td>78586</td>
<td>Pulmonary ventilation imaging, aerosol; single projection</td>
</tr>
<tr>
<td>78587</td>
<td>Pulmonary ventilation imaging, aerosol; multiple projections (e.g., anterior, posterior, lateral views)</td>
</tr>
<tr>
<td>78588</td>
<td>Pulmonary perfusion imaging, particulate, with ventilation imaging, aerosol, one or multiple projections</td>
</tr>
<tr>
<td>78591</td>
<td>Pulmonary ventilation imaging, gaseous, single breath, single projection</td>
</tr>
<tr>
<td>78593</td>
<td>Pulmonary ventilation imaging, gaseous, with rebreathing and washout with or without single breath; single projection</td>
</tr>
<tr>
<td>78594</td>
<td>Pulmonary ventilation imaging, gaseous, with rebreathing and washout with or without single breath; multiple projections (e.g., anterior, posterior, lateral views)</td>
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<tr>
<td>78596</td>
<td>Pulmonary quantitative differential function (ventilation/perfusion) study</td>
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<td>78600</td>
<td>Brain imaging, limited procedure; static</td>
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<td>78601</td>
<td>Brain imaging, limited procedure; with vascular flow</td>
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<tr>
<td>HCPCS Codes</td>
<td>Description</td>
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<td></td>
<td>No specific codes</td>
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<tr>
<td>ICD-9-CM Diagnosis Codes</td>
<td>Description</td>
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<td>-------------------------</td>
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<td>Multiple/varied codes</td>
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References


