

## CARDIOVASCULAR IMAGING - SPECIAL GUIDELINE

### Guideline for Rest and Stress Myocardial Perfusion Scintigraphy

Authors: Bárbara Juarez Amorim<sup>1</sup> and Cláudio Tinoco Mesquita<sup>2</sup>

Colaborators: Elaine Bortoleti de Araújo<sup>3</sup>, Tadeu Kubo<sup>4</sup>, Solange Nogueira<sup>5</sup>, Marissa Rivera<sup>6</sup>

Nuclear Medicine Physician of Nuclear Medical Services at *Universidade Estadual de Campinas (Unicamp), Campinas-SP* and Director at SBMN,<sup>1\*</sup> Nuclear Medical Services at *Hospital Universitário Antonio Pedro - Universidade Federal Fluminense* and *Hospital Pró-Cardíaco, Rio de Janeiro-RJ* and President da SBMN,<sup>2\*</sup> Quality Assurance Manager, Radiopharmacy Center, Nuclear and Energy Research Institute (IPEN),<sup>3</sup> *São Paulo*, HUCFF physicist, *Rio de Janeiro - RJ* and Coordinator of the Department of Medical Physics at SBMN,<sup>4\*</sup> Biomedical at *Hospital Albert-Einstein, São Paulo-SP* and Coordinator of the Technologists and Biomedics Department at SBMN,<sup>5\*</sup> Medical Application and Research Division, Nuclear Energy National Commission (CNENE),<sup>6</sup> *Rio de Janeiro, RJ - Brazil*

\* SBMN – Brazilian Society of Nuclear Medicine (2015-2016 administration)

#### Abstract

This is an article about Guidelines for Rest and Stress Myocardial Scintigraphy. It was developed and written by the Brazilian Society of Nuclear Medicine to serve as a best-practices guidelines used in Nuclear Medicine. It is an educational tool to help Nuclear Medicine Services in Brazil to guarantee a quality care to the patients.

#### General information about the exam:

Diagnostic imaging exam used to assess myocardial blood distribution at rest and stress.

#### Indications:

1. Symptomatic patients or patients with ECG suggestive of ischemia, with intermediate or high pre-test probability;
2. Symptomatic patients or patients with ECG suggestive of ischemia, with low pre-test probability who are unable to perform a stress test, or with an uninterpretable ECG (left branch block, preexcitation, medication that interferes with the ECG or with chronotropism);
3. Asymptomatic patients with high pre-test probability of coronary artery disease, calcium score between 100-400 or > 400 and intermediate risk;

#### Keywords

Myocardial Perfusion Imaging / radionuclide imaging; Practice Guideline; Diagnostic Imaging.

4. Moderate-risk pre-operative patients of non-cardiac surgery or vascular surgery with one or more risk factors and poor functional capacity:
  - a. Clinical risk factors: previous history of coronary artery disease (CAD), history of heart failure, history of cerebrovascular disease, diabetes mellitus or kidney failure (serum creatinine over 2 mg/dL);
5. General surgery pre-operative stratification in patients with confirmed heart disease: recent acute myocardial infarction (AMI) – last six months, unstable angina, decompensated heart failure and severe valve disease;
6. High or intermediate risk general surgery pre-operative stratification in patients with functional capacity  $\leq 4$  METS, or patients whose functional capacity is impossible to assess when at least one of the following risk factors is present: previous history of CAD, history of heart failure, history of cerebrovascular disease, diabetes mellitus, or kidney failure (serum creatinine over 2 mg/dL);
7. After coronary artery bypass surgery (>3 months) in symptomatic patients, if the surgery was incomplete, or if the procedure was over five years before;
8. Patients with known coronary anatomy, with need for identification of the vessel related to the ischemia (definition of the hemodynamic meaning of coronary lesions);
9. Assessment of myocardial viability in severe ventricular dysfunction patients (left ventricle ejection fraction < 40%) with suspected or confirmed CAD;

#### Mailing Address: Bárbara Juarez Amorim

Universidade Estadual de Campinas - Unicamp  
Rua Vital Brasil, 251 - Campinas/SP. Postal Code: 13083-888. Cidade Universitária Zeferino Vaz, Campinas, SP – Brazil.  
E-mail: juarezbarbara@hotmail.com

10. For risk evaluation and stratification of known CAD patients undergoing medication therapy after 6 months of beginning and/or alteration of treatment;
11. Patients with suspected CAD who underwent previous exams with inconclusive or conflicting results:
  - a. Patients with diabetes mellitus (for at least ten years or with diabetic microangiopathy or risk factors for CAD, such as systemic arterial hypertension, smoking, dyslipidemia, or family history of early onset CAD);
  - b. Patients with evidence of documented atherosclerosis by complementary exams;
12. Patients with Framingham risk score  $\geq 20\%$  of events in 10 years.

**Relative Contraindications:** pregnancy and breastfeeding.

**Duration of the exam:** approximately 3-4 hours.

**Preparation:** If the requesting physician wishes to diagnose coronary artery disease, heart medications must be suspended (beta-blockers and calcium channel blockers 3 days prior, vasodilators, 24 hours prior). If the requesting physician wishes to see the effect of therapeutic medications, heart medications do not need to be suspended.

Avoid heavy meals during the exam.

Remove metal objects from the chest region that may attenuate the heart (coins, prostheses).

### Stress test

Stress tests must be carried out by a trained doctor.

All required conditions for cardiovascular resuscitation in the cardiac stress test facility must be available.

**Stress Test** – The test may be done on a treadmill or stationary bike, under medical supervision. Stress level must be chosen by the physician, which adds prognostic information to the exam; 4-hour fasting prior to the exam, suspend beta-blockers for 48 hours if clinically possible; the patient must be hemodynamically stable for 48 hours prior to the stress test; the test should preferably not be done in patients with total left bundle branch block (opt for pharmacological test with vasodilators).

Absolute contraindications to physical stress:

1. High risk unstable angina;
2. Decompensated heart failure;
3. Uncontrolled hypertension (SBP > 200 mmHg and DBP > 110 mmHg at rest);
4. Uncontrolled cardiac arrhythmias;
5. Acute myocardial infarction on the first days of evolution (< 2-days), even if stable;
6. Acute pulmonary embolism;
7. Acute aortic syndrome (dissection, intramural hematoma, penetrating ulcer);
8. Severe symptomatic aortic stenosis;
9. Severe pulmonary arterial hypertension;
10. Acute myocarditis or pericarditis;
11. Any unstable acute clinical conditions such as sepsis, acute anemia.

Contraindications relative to physical stress:

1. Previously known significant left coronary trunk lesion;
2. Severe asymptomatic aortic stenosis;
3. Electrolyte disturbances;
4. High-grade atrioventricular block;
5. Obstructive hypertrophic cardiomyopathy.

**Pharmacological Test with Vasodilators** (dipyridamole, adenosine) – suspend beverages containing caffeine (coffee, tea) and medication containing methylxanthines 12 hours prior to the exam. A 0.56 mg/kg dose of dipyridamole is administered intravenously in 4 minutes. Peak vasodilation occurs 6.5 minutes after the beginning of infusion and the radiotracer must be administered 3 to 5 minutes after dipyridamole infusion is finished. Administration 1 minute after radiotracer administration of 50 mg – 250 mg of aminophylline intravenously is employed to reverse dipyridamole's side effects (this is not necessary for adenosine due to its short half-life).

**Contraindications:** History of severe bronchospasm; asthma during physical activity; severe aortic stenosis; severe obstructive hypertrophic cardiomyopathy; pregnancy or lactation. Adenosine and dipyridamole must not be used in patients with 2° or 3° degree atrioventricular block and atrial node disease, arterial hypotension (SP < 90 mmHg) or history of allergy to these medications.

**Pharmacological Test with Inotropic/ Chronotropic agent** (dobutamine) – Dobutamine is infused through

an infusion pump in incremental doses starting at 5-10 mcg/kg/min, increasing to 20, 30 and 40 mcg/kg/min every three minutes. It is preferable that the radiotracer be injected after one minute of the maximum dose of dobutamine and at a heart rate of over 85% of the maximum HR. The use of isometric exercise or doses of 2 mg of atropine may help increase the heart rate. Dobutamine is employed if physical stress or use of vasodilators cannot be executed. Four hours of fasting must be observed and beta-blockers must be suspended if clinically possible. Generally, it is used in patients with obstructive pulmonary disease or other contraindications to stress with vasodilators.

**Contraindications:** ventricular tachyarrhythmia; uncontrolled arterial hypertension. Should be used cautiously in patients with unstable angina, recent AMI, hypertrophic or obstructive cardiomyopathy.

**Pertinent Information on the Procedure:** It is important to do a cardiorespiratory physical exam, including vital signs; disclose use of medication, symptoms, risk factors for coronary artery disease, previous history of diagnostic or cardiovascular treatment procedure (catheterization, revascularization); observe pathologies that increase the risk of stress such as unstable angina, obstructive hypertrophic cardiomyopathy, aortic valve stenosis, carotid stenosis, obstructive respiratory disease that may contraindicate the test with vasodilators; do a basal electrocardiogram to detect acute ischemia, left bundle branch block, arrhythmias.

**Radiopharmaceutical:** sestamibi-<sup>99m</sup>Tc, tetrofosmin-<sup>99m</sup>Tc

Note: Thallium-201 is not recommended for **rest and stress myocardial** scintigraphy due to its considerably larger dose of radiation. There is an exception when myocardial viability needs to be evaluated, in which case, thallium-201 is indicated.

**Marking and quality control:** Marking and quality control must be done according to manufacturer guidelines. However, pharmacopoeial criteria must be respected (pH between 5.0 – 6.0 and radiochemical purity  $\geq 90\%$ ).

#### Adult activity:

a) Technetium 99m chelating agents - sestamibi or tetrofosmin

1-day protocol: do not exceed 40mCi in total; stress dose must be 3 times the rest dose (e.g., rest 8mCi, stress 24 mCi).

2-day protocol: stress in one day and rest on another day (dose of 10 to 30 mCi for each injection).

b) Thallium-201: if thallium-201 is to be used, do not exceed 3.5 mCi in total (due to a larger absorbed dose associated to this tracer, it is used, preferably, in myocardial viability research protocols). Myocardial viability research protocols may include reinjection after redistribution phase acquisition of 4 hours and late images of 24 hours to detect viable areas.

Note: Because of the continuous search for radiation exposure reduction (optimization), several actions must be taken:

1. IAEA 2015 recommends a maximum dose at rest of 9 mCi, and a stress dose of three times the rest dose, without exceeding a total dose of 36 mCi.
2. It is considered good practice to adjust the activity to be injected by body weight. In relation to agents linked to technetium-99m, there is a recent international recommendation that patients with a normal body mass index (BMI) receive 8-12 mCi per phase in 2-day protocols, and patients with increased BMI receive 18-30 mCi per phase in 2-day protocols.
3. For 1-day protocols, the dose can also be adjusted by BMI: 8 mCi for BMI < 25; 9 mCi for BMI 25-30; 10 mCi for BMI 30-35; 12 mCi for BMI > 35.
4. 2-day protocols are preferable for the reduction of background residual activity. However, this may not be viable in several situations, especially for patients in emergency rooms. To reduce background residual activity in a 1-day protocol, an activity of at least three times in the second phase must be administered, and there must be an interval of at least two hours between radiotracer injections. The 1-day protocol may allow a suppression of the 2-hour interval, if the second phase activity is elevated to 3.5 to 4 times the initial activity due to the proportionate increase of the count.
5. Obese patients (over 113 kg, for example, as cited by ASNC guidelines) should preferably not be booked for 1-day protocols due to the increased likelihood of low count images and higher statistical fluctuation (noise).
6. The use of new cameras with solid state detectors (CZT) allows the use of activities that are lower than normal in several protocols or accelerated acquisition protocols.

### Acquisition:

Collimator: high resolution

Energy: window of 15% in 140 keV

Thallium-201: start stress acquisition as soon as the heart rate returns to near basal levels, within a maximum of 10 minutes.

Agents with technetium-99m: start acquisition after 45-60 minutes of injection at rest. In the case of physical stress, start within 15-30 minutes of the injection. In the case of stress by vasodilators, start images after 30-60 minutes.

Positioning: Patient in the supine position, left arm lifted above the head, and right arm on the side. Collimator as close to chest as possible. Set three ECG derivations.

Projection: tomographic image (SPECT)

180-degree SPECT, circular, elliptical or non-circular orbit (proximity detectors).

SPECT must start at 45 degrees (right anterior oblique) and finish at left posterior oblique.

Steps every 3 – 6 degrees

Matrix 64x64

Time per step: Generally, approximately 40 sec/step for thallium-201 and rest acquisition of agents with technetium-99m, and around 25 sec/step for technetium-99m stress acquisition.

Images must be synchronized with the electrocardiogram (GATED) whenever possible, at rest and during stress.

Note: In arrhythmia patients, GATED may be canceled. When heartbeat rejection is over 10% in patients without arrhythmia, check electrode connection and/or change its position.

Stress synchronized to the electrocardiogram (GATED SPECT)

On the treadmill, 15 minutes after venous injection of the tracer. When the stress is pharmacological, 30 minutes after the injection.

### Optional Images

Imagem com mama rebatida – same projection, but with mama rebatida to eliminate attenuation artifact in the anterior wall.

Prone image – prone patients, SPECT 180 degrees starting in the anterior oblique; image to eliminate or reduce attenuations such as diaphragm, abdomen and breast attenuation.

### Image review

Before processing, acquisition images must be seen in cine to detect patient movement that may lead to artefacts. If there is significant movement, the study must be acquired again. Before proceeding to study interpretation, images must be revised to avoid possible sources of artefacts such as patient movement, aforementioned sources of attenuation and possible procedure errors.

### Attenuation correction by computed tomography (CT)

For equipment with an attached CT, attenuation correction by the CT is helpful in reducing attenuation of photons from aforementioned causes (diaphragm, breast, etc). However, some of the available software and hardware result in artefacts. Thus, corrected and non-corrected images must be interpreted to reduce sources of errors. Moreover, since errors in attenuation correction map and emission data may be a possible source of artefacts, a merged image showing the relation between these two files must be revised before analysing the images corrected for attenuation.

### Author contributions

Conception and design of the research: Amorim BJ, Mesquita CT. Acquisition of data: Amorim BJ, Mesquita CT. Analysis and interpretation of the data: Amorim BJ, Mesquita CT, Araújo EB, Kubo T, Nogueira S, Rivera M. Statistical analysis: Amorim BJ, Mesquita CT. Writing of the manuscript: Amorim BJ, Mesquita CT. Critical revision of the manuscript for intellectual content: Amorim BJ, Mesquita CT, Araújo EB, Kubo T, Nogueira S, Rivera M.

### Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

### Sources of Funding

There were no external funding sources for this study.

### Study Association

This study is not associated with any thesis or dissertation work.

## Bibliographies

1. Strauss HW, Miller DD, Wittry MD, Cerqueira MD, Garcia EV, Iskandrian AS, et al. Procedure Guideline for Myocardial Perfusion SNM Imaging 3.3. *J Nucl Med Technol.* 2008;36(3):155-61.
2. Einstein AJ, Pascual TNB, Mercuri M, Karthikeyan G, Vitola JV, Mahmarian JJ, et al. Current worldwide nuclear cardiology practices and radiation exposure: results from the 65 country IAEA Nuclear Cardiology Protocols Cross-Sectional Study (INCAPS). *Eur Heart J.* 2015;36(26):1689-96.
3. Wolk MJ, Bailey SR, Doherty JU, Douglas PS, Hendel RC, Kramer CM, et al. ACCF/AHA/ASE/ASNC/HFSA/HRS/SCAI/SCCT/SCMR/STS 2013 Multimodality Appropriate Use Criteria for the Detection and Risk Assessment of Stable Ischemic Heart Disease: A Report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and Society of Thoracic Surgeons. *J Am Coll Cardiol.* 2014;63(4):380-406.
4. Dorbala S, Di Carli MF, Delbeke D, Abbara S, DePuey EG, Dilsizian V, et al. SNMMI/ASNC/SCCT Guideline for Cardiac SPECT/CT and PET/CT 1.0. *J Nucl Med.* 2013;54(8):1485-507.
5. Patel MR, White RD, Abbara S, Bluemke DA, Herfkens RJ, Picard M, et al. ACCF/ACR/ASE/ASNC/SCCT/SCMR Appropriate Utilization of Cardiovascular Imaging in Heart Failure: A Joint Report of the American College of Radiology Appropriateness Criteria Committee and the American College of Cardiology Foundation Appropriate Use Criteria Task Force. *J Am Coll Cardiol.* 2013;61(21):2207-31.
6. Agência Nacional de Saúde Complementar (ANS). Diretrizes de utilização para cobertura de procedimentos na saúde suplementar : rol de procedimentos e eventos em saúde 2016 .[Internet]. [Citado em 2016 abr 10]. Disponível em: [http://www.ans.gov.br/images/stories/Plano\\_de\\_saude\\_e\\_Operadoras/Area\\_do\\_consumidor/rol/rol2016\\_diretrizes\\_utilizacao.pdf](http://www.ans.gov.br/images/stories/Plano_de_saude_e_Operadoras/Area_do_consumidor/rol/rol2016_diretrizes_utilizacao.pdf)
7. Henzlova MJ, Duvall WL, Einstein AJ, Travin MI and Verberne HJ. ASNC Imaging Guidelines for SPECT Nuclear Cardiology Procedures: Stress, Protocols, and Tracers. *J Nucl Cardiol.* 2016;23(3):606-34.