The Symptomatic Patient with Known/Suspected CAD

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The Symptomatic Patient with Known CAD

• MPI provides valuable diagnostic and prognostic information in patients with known CAD

• Normal Study = low event rate

• Recommendations:
  – Focus on optimizing image quality
  – Focus on optimizing sensitivity of test for detection of ischemia
    • Rest/Stress Tc-99m or 2-day protocol
  – Radiation exposure less of a concern
One-Day Tc-99m Rest/Stress Protocol

Advantages

• The rest/stress imaging protocol can be completed within 3 hours.
  – This time can be further reduced to under 2 hours when using new ultrafast camera systems, where image acquisition can be completed in as little as 2 minutes with potentially shorter waiting periods after isotope injection.

• Stress and rest SPECT images are both performed using a Tc-99m radiopharmaceutical.
  – Therefore, spatial resolution, attenuation artifacts, and Compton scatter are relatively similar in the stress and rest images, simplifying interpretation and assessment of fixed versus reversible perfusion defects.

• By acquiring both stress and rest perfusion tomograms, one can evaluate transient ischemic dilatation.
  – TID is an abnormality often associated with severe and/or multivessel stress-induced ischemia.

• If both the rest and stress SPECT acquisitions are gated, it may be possible (depending on image quality) to compare rest and post-stress left ventricular (LV) function and thereby evaluate stress-induced global and regional dysfunction.
  – This may increase sensitivity for detecting balanced stress-induced ischemia.
One-Day Tc-99m Rest/Stress Protocol

Disadvantages

• Performing the rest study first delays the laboratory schedule
  – It may inconvenience the individual supervising the stress test.

• Since stress SPECT will always be performed with residual resting myocardial activity present in the patient, the resting activity "shine through" into the subsequent stress scan
  – This could theoretically decrease coronary artery disease (CAD) detection (i.e., sensitivity) or underestimate patient risk by decreasing the stress-induced perfusion defect size and severity.

• The relatively low (approximately 8-12 mCi) rest dose may result in suboptimal count density with resultant poor image quality and associated artifacts.
  – This will be particularly evident in larger patients. Moreover, comparison of the low-dose rest to the high-dose stress image may be problematic depending on the degree of differences in count density between the images. Ischemia may also be underestimated, as some defects may appear fixed rather than reversible due to low-count rest images, especially when attenuation is present. Lastly, low-count density may preclude accurate quantification of resting LV volumes and ejection fraction (EF) when performing either 8- or 16-frame gated SPECT. This limitation in part confounds one’s ability to assess stress-induced regional and global LV dysfunction.

• Since the resting scan is performed first, a subsequent stress scan must be performed in every patient.
  – This obviates the advantage of employing a stress-only protocol (see below).
One-Day Tc-99m Stress/Rest Protocol

Advantages

• Both the stress and rest SPECT images are performed using a Tc-99m radiopharmaceutical.
  – Therefore, spatial resolution, attenuation artifacts, and Compton scatter are relatively similar in the stress and rest images.

• There is no delay in stressing the patient.
  – This feature is attractive to the individual supervising the stress test. Moreover, if treadmill exercise is performed or if pharmacologic stress is supplemented with low-level exercise, the stress injection-to-imaging interval may be as short as 20 minutes, further improving laboratory efficiency.

• If the stress images are normal, rest imaging is unnecessary.
  – Attenuation correction techniques may decrease or eliminate soft tissue attenuation artifacts, thereby increasing the number of stress SPECT scans judged to be normal and decreasing the need for subsequent resting SPECT. This “stress-only“ approach significantly shortens the protocol, thereby enhancing patient satisfaction and convenience and decreasing patient radiation exposure by avoiding administration of the higher rest dose. Stress-only imaging also conserves Tc-99m and decreases cost by eliminating the higher rest dose of Tc-99m.
One-Day Tc-99m Stress/Rest Protocol

Disadvantages

• From a theoretical perspective, a stress/rest protocol may underestimate ischemia (i.e., defect reversibility) due to “shine through” from the stress activity into the rest image.
  – Although a low dose of Tc-99m is administered to the patient for the initial stress scan there is increased delivery of tracer to the myocardium due to stress induced hyperemia. There are several solutions to avoid “shine through”: 1) the rest dose can be increased; 2) the stress dose can be allowed to decay; or 3) all of the above approaches can be implemented to a relative extent depending on the individual patient. Since the physical half-life of Tc-99m is 6 hours, a delay of approximately 3-4 hours from the time of stress to rest injection is recommended if the rest imaging time or injected dose are not appropriately adjusted.

• Because the stress dose is relatively low (8-12 mCi), the stress images may be prone to artifacts.
  – Artifactual defects on the stress image may be less apparent on the subsequent higher count density rest image resulting in erroneous interpretation of defect reversibility (ischemia). This is the converse argument to the one described above where ischemia is said to be underestimated with a stress/rest protocol. To avoid these potential interpretation dilemmas, patients with a large chest circumference should generally undergo a high dose two-day stress/rest Tc-99m imaging protocol rather than either a one day stress/rest or rest/stress protocol.

• Post-stress stunning may be difficult to assess due to suboptimal count density of the gated images.
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Two-Day Stress/Rest Tc99m Protocol

This protocol is considered to provide optimal image quality and is performed as follows:

**DAY #1**
- 24-36 mCi Tc99m-based radiopharmaceutical is injected at peak exercise or pharmacologic stress with imaging performed approximately 15-20 minutes post-exercise or approximately 30-60 minutes post-pharmacologic stress.

**DAY#2**
- 24-36 mCi Tc99m-based radiopharmaceutical is injected at rest with imaging performed approximately 30-60 minutes thereafter.
Two-Day Stress/Rest Tc99m Protocol

Advantages

• There is no delay in stressing the patient.
• If stress SPECT is normal, rest imaging is unnecessary (i.e., stress-only imaging).
• The stress and rest SPECT images are performed using a Tc-99m radiopharmaceutical and at a similar dose.
  – Therefore, spatial resolution, attenuation artifacts, and Compton scatter will be relatively similar on the stress and rest images; and both gated datasets will be of comparable quality facilitating image interpretation and recognition of post-stress stunning.
• The two-day stress/rest protocol is particularly well-suited for obese patients and patients in whom attenuation artifacts are anticipated (women with large breasts or implants, patients with diaphragmatic elevation, etc.).
  – However, in such patients, higher count density still does not eliminate the problems of soft tissue scatter and loss of spatial resolution with depth.
• By acquiring both stress and rest perfusion tomograms, one can evaluate transient ischemic dilatation, an abnormality often associated with severe and/or multivessel stress-induced ischemia.
• If both the rest and stress SPECT acquisitions are gated, it is possible to accurately compare them and thereby evaluate stress-induced global and regional LV dysfunction.
  – Since the stress and rest gated SPECT tomograms are of comparable count density and quality, the two-day protocol may be more reliable than the single day one for detecting changes in LV function associated with balanced stress-induced ischemia.
Two-Day Stress/Rest Tc99m Protocol

Disadvantages

• Two days of imaging are required if the initial stress study is not unequivocally normal.
• Higher patient radiation dose than single-day rest/stress or stress/rest protocol
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Software and Hardware Solutions to Decrease Patient Radiation Dose Using a Rest/Stress or Two-Day Protocol

• Encourage increased SPECT acquisition time, as tolerated by patients, in preference to weight-base dosing in large patients
Modification of SPECT Acquisition Time to Yield Adequate Myocardial Count Density

Unique Count-Based SPECT ACQ
- Consistent inter-patient data integrity

Automated ACQ Technique that ensures ASNC Quality Standards
- At least 60 or 64 projections at 44,000 counts
- At least 30 or 32 projections at 20,000 counts
- 22,000 counts in the heart, stress LAO
- 10,000 counts in the heart, rest LAO

Easy Positioning
- Cardiocentric patient positioning tool

NOTE: Myocardial count rate determined from user defined regions of interest for the three detector heads.

Digirad TruACQ,Courtesy Digirad Corp.
Software and Hardware Solutions to Decrease Patient Radiation Dose Using a Rest/Stress or Two-Day Protocol

• Utilize new reduced count-density software and new solid-state camera technology to decrease injected activity
Half-dose R/S (7.3/17.5 mCi) Tc-99m sestamibi WBR

63 y.o. male, known CAD
HTN, ↑cholesterol
Prior PCI
5’7”, 275 lbs, 50” chest

Fixed inferoapical defect c/w scar
60 y.o. male S/P MI, recurrent chest pain

Severe, extensive inferolateral scar
Moderately extensive, mild anterior ischemia

Discovery NM 530c
2 min stress/ 4 min rest

Courtesy, Ernest Garcia, Ph.D.
The Symptomatic Patient with Suspected CAD

• Appropriate in patients with unexplained chest pain or symptoms suggestive of ischemia
• 50-60% of symptomatic patients will have normal imaging and low event rates

• Recommendations:
  – Stress-first (potentially stress-only) imaging
    • Can be performed in > 25% of all patients referred for MPI
    • Reduces radiation exposure
    • Increases laboratory efficiency
Stress-Only Tc-99m Protocol

In a recent ASNC information statement, stress-only imaging was recommended when applied to properly selected patients. In order to perform stress-only imaging, either a one-day or two-day stress-rest Tc-99m imaging protocol must be used. The choice of imaging protocol will depend on patient body weight and habitus.

Two large trials evaluating over 21,000 patients with a normal SPECT study have demonstrated the safety of stress-only imaging as compared to traditional stress/rest imaging. Comparably low all-cause and cardiac mortality rates were observed with both imaging protocols. This was true irrespective of patient age, gender, cardiac risk factor profile or stressor employed with SPECT. These results are consistent with earlier studies evaluating patient outcome following normal stress-only imaging. The stress Tc-99m imaging procedure is identical to that described above.

Stress-Only Tc-99m Protocol

Advantages

• Patient convenience/satisfaction and laboratory efficiency are improved.

• There is a significant reduction in patient radiation exposure by eliminating the higher rest Tc-99m dose.
  – In one recent study, the mean Tc-99m dose was significantly lower at 21.3±10.7 mCi with stress-only vs. 55.1±11.9 mCi with stress/rest imaging. This was particularly true for patients who received an initial low dose of Tc-99m as part of a same day stress/rest protocol (13.5±2 mCi).5

• Conservation of Tc-99m radiopharmaceuticals

• Reduced cost by eliminating injection of a second Tc-99m dose and the subsequent rest imaging
Stress-Only Tc-99m Protocol

Disadvantages

• There are no specific disadvantages to a stress-only imaging approach.
  – When properly utilized a normal stress-only study predicts the same excellent prognosis as compared to standard stress/rest imaging. However, there are specific issues that need to be considered prior to implementing stress-only imaging in an individual laboratory:

• First, there is a requirement to assess each patient on arrival to the laboratory to choose the most appropriate imaging protocol rather than a “one test fits all” approach.

• Differentiation of artifact from a true perfusion abnormality is more difficult without a resting scan and therefore requires the expertise of an experienced reader.
  – In this regard, attenuation correction with either x-ray computed tomography (CT) or line sources may be advantageous if a stress-only protocol is used. Recent data indicate that a stress-only imaging protocol coupled with attenuation correction techniques can be effectively applied to obese patients where a normal study predicts an excellent outcome. Prone imaging can also be used to clarify inferior perfusion defects due to diaphragmatic attenuation observed on supine images.

• The perfusion images should be unequivocally normal by visual and, preferably, quantitative analysis and LV cavity size, LVEF and regional wall motion and thickening should be normal.
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Ultra-Low Dose Protocol
D-SPECT®, Spectrum Dynamics

Supine

Prone

Stress-Only Protocol
55 yo male
BMI 28.5

3.2 mCi