Prone-only SPECT myocardial perfusion imaging: An alternative standard in clinical practice?

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Myocardial perfusion imaging (MPI) using single photon emission computed tomography (SPECT) is the most common non-invasive test for diagnosis of coronary artery disease (CAD), risk stratifying of patients after infarction, assessing myocardial viability, and planning therapy.[1] Coronary angiography is still the gold standard test for detecting CAD; however, this is an invasive method with a broad range of risks and complications (such as hemorrhage, endothelial injuries, and hematoma).[2] SPECT-MPI is usually performed with the patient in the supine position with the arms raised above the head and supported.[3,4] It is, however, recognized that the diaphragmatic attenuation of the inferior wall and the breast attenuation of the anterior wall in females has an impact on the test specificity.[1,3–7] In addition, there is potential for loss of sensitivity, as perfusion defects may be interpreted as attenuation artifacts. Planar acquisition, prone imaging, ECG gating, and image quantitation constitute commonly used approaches to overcome soft tissue attenuation. Although direct approaches for attenuation correction have been commercially available, they are quite expensive and possibly not provided to all nuclear medicine departments.[1,8] Prone imaging has been shown to reduce patient motion and reduce inferior wall attenuation, improve the specificity and accuracy of inferior wall defect detection, and decrease the frequency and degree of patient motion.[9–11] Segall et al. [9,10]) initially described SPECT-MPI with data acquisition in the prone position. Subsequently, other studies with ^{201}Tl or ^{99m}Tc-sestamibi SPECT-MPI showed that imaging acquisition in the prone position improves the specificity for evaluating inferior wall abnormalities by minimizing diaphragmatic attenuation.[12,13] However, the routine change of supine to prone imaging is a controversial matter, given the occasionally seen artifactual anterior-anteroseptal wall prone defect.[11,13,14] This finding is presumably attributed to sternal and/or rib attenuation.[1,4] The majority feels that prone should be considered only when imaging in the supine position raises the question of true inferior wall perfusion defect or artifact abnormality.[4,11,13] No evidence from larger series is available as to which position is better in routine work. If interpretation of a study obtained in the supine position is hampered by infradiaphragmatic attenuation or scatter, an additional acquisition in the prone position may be tried. As Taasan and colleagues[15] correctly point out the benefits of prone imaging include downward displacement of the diaphragm and abdominal organs, compression of anterior chest soft tissue including breast tissue, a shift of the heart more anteriorly, and reduction of patient motion. There is no doubt that attenuation correction decreases equivocal studies compared to prone imaging.[16] However, in the same study utilizing ^{99m}Tc- based rest and stress imaging with attenuation correction, prone imaging, and prone and supine imaging without attenuation correction, prone imaging significantly reduced equivocal studies.[16] Indeed, even with a state-of-the-art SPECT-CT system imaging may reduce the incidence of apical artifacts.[17] Stathaki et al.[18] showed that the addition of prone position to stress supine myocardial scintigraphy decreases the false-positive rates and leads to more accurate results. The prone position, which moves the diaphragm downward and the heart upward, enlarges the distance between the inferior wall of the left ventricle and diaphragm, and minimizes diaphragmatic

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attenuation.[19] Furthermore, it increases specificity without compromising sensitivity for the diagnosis of CAD.[18] Segall and Davis[10] demonstrated that specificity for right coronary artery was dramatically better (90% versus 66%) when patients were submitted to prone image acquisition compared to supine. Moreover, the overall effect on the detection of CAD was an improved accuracy and higher specificity (82% versus 59%) without significant loss of sensitivity (75% versus 79%). In addition, Hayes et al.[4] concluded that patients with inferior wall defect in the supine position that was not present in the prone image had similar low risk of cardiac events, when compared with those that had normal supine only studies. Katayama et al.[20] demonstrated the diagnostic accuracy of ^{201}Tl stress prone SPECT images for detecting CAD in the inferior wall of the left ventricle compared with that of stress–rest supine images. In particular, they found a tendency toward improved specificity and decreased false-positive rates. Shin et al.[14] in a large study examined the ability CAD as determined by coronary angiography. They found that prone SPECT-MPI demonstrated high sensitivity for detection of CAD (92% for stenosis $\geq$ 70%) and high normalcy rate (95%). They also found no significant difference in the normalcy rate among the three coronary distributions when assessed in the prone position.[14] As is standard practice in nuclear cardiology reports, normalcy rate was used as a proxy for specificity given the inherent post-test referral bias in populations of patients who have been selected after referral for cardiac catheterization after an abnormal SPECT-MPI. Their results suggest that a prone-only imaging protocol can be considered a reasonable option for SPECT-MPI. It seems that prone imaging might have an additional role in preventing unnecessary coronary angiograms and minimize radiation exposure, especially in low-risk patients. Recently, Worden et al.[21] showed that patients with perfusion abnormalities during stress supine imaging that resolved during prone imaging are at low risk for cardiac death or myocardial infarction at medium-term follow up. Given that they seldom require invasive coronary angiography, broader application of prone imaging could lead to reduced exposure to the risks and expenses of unnecessary invasive procedures.[21] Anterior wall defects are most common in women. Although some believe that positional change mainly contributes to the disappearance rate of diaphragmatic attenuation,[11,22] it is a confirmed knowledge that combined supine and prone approach improves specificity and normalcy rates in women. Slomka et al.[23] reported no differences in normalcy rates between prone and supine acquisitions in a population of women. In this study, they also find similar normalcy rates in each of the three coronary distributions, further suggesting that these concerns may be overstated. More recently, the new cadmium zinc telluride (CZT) cameras have made a significant difference in evaluation of patients for CAD.[24,25] Nishiyama et al.[26] assessed the feasibility of combined imaging using a novel ultrafast CZT camera. They concluded that the combined supine and prone CZT SPECT yields significant gains in specificity and accuracy, whereas acquisition time is reduced by up to one fifth. However, troublesome artifact effects of the inferior wall exist similarly to those on images obtained with conventional Anger cameras.

In the current issue of the Journal, Mirshahvalad et al.[27] conducted a systematic review and meta-analysis aimed to evaluate the diagnostic performance of the prone position in detection of CAD as an independent standard. The authors reviewed and analyzed 10 articles evaluated the prone position MPI as a diagnostic method to detect the CAD. They included studies that defined CAD with coronary angiography, using the threshold of $\geq$50% stenosis and provided adequate data to extract the sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of SPECT-MPI in detecting CAD. They separated the articles that provided data for the prone position in all territories (PAT) and the right coronary artery territory (PRT). Their results showed that the pooled sensitivities of the studies were 83% (95% confidence interval, CI 0.79-0.86), 70% (95% CI 0.59-0.79), and 86% (95% CI 0.83-0.88) for PAT, PRT, and supine all territories (SAT), respectively. The pooled specificities of the studies were 79% (95% CI 0.72-0.85), 84% (95% CI 0.79-0.88), and 67% (95% CI 0.59-0.74) for PAT, PRT, and SAT, in turn.[27] The results of this meta-analysis emphasize the role of prone-only SPECT-MPI. The authors showed that in the suspicion for the CAD, prone position with comparable sensitivity and higher specificity can be an acceptable alternative to the supine position as the standard method, also in the cases of possible defects in the right coronary artery territory.[27] Despite the benefits of prone imaging, the specific manner in which it should be employed in standard clinical practice remains unclear. Many laboratories currently perform prone-only imaging for patients who are unable to lie supine or when severe diaphragmatic attenuation is expected. Recent guidelines of the American Society of Nuclear Cardiology[28]) recommend supine position as the standard for SPECT- MPI with most currently available Anger and CZT systems; the routine use of 2-position imaging, combination of supine followed by prone acquisition or upright and supine imaging, is recommended, at least for stress images, particularly if attenuation correction is not available. By comparing supine and prone images, artefactual defects will resolve or change their location whereas true perfusion defects will remain in the same

position.[3,13] When being used in this fashion, the acquisition time for the secondary (prone) image set can be reduced by 20% to 40%.[26] Moreover, the addition of prone position to stress supine myocardial scintigraphy results in the key benefit of reducing the number of unnecessary rest studies performed, while minimizing radiation exposure, investigation time, and costs.[18] It could possibly be a useful and practical method of obviating unnecessary referrals to coronary angiograms, especially in low-risk patients.[18] In this scenario, prone SPECT-MPI should not be used alone, making the routine change of supine to prone imaging still debated. Therefore, further studies in larger patient populations are needed to standardize the use of prone SPECT-MPI in clinical routine practice.

Disclosure

Valeria Cantoni, Roberta Green, and Alberto Cuocolo declare that they have no conflicts of interest.

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