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Clinical correlation between increased lung to heart ratio of tecnetium-99m sestamibi and multivessel coronary artery disease

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Abstract

Background: An increased lung to heart ratio (LHR) on thallium-201 (Tl-201) stress myocardial perfusion imaging (MPI) is a predictor of adverse cardiac events and identifies people with extensive coronary artery disease (CAD). The implications of increased LHR in patients undergoing stress technetium-99m (tc-99m) sestamibi are developing. Our aim is to evaluate the relationship between increased LHR and extent of CAD in patients undergoing tc-99m sestamibi MPI. *Methods:* We reviewed the records and images of 530 consecutive subjects who underwent exercise or adenosine tc-99 m sestamibi MPI. One hundred thirty-two had transient or partially reversible myocardial perfusion defects and 79 (exercise = 34, adenosine = 45, male = 43, female = 36, mean age = 61 years) of these underwent coronary angiography (study population). The average LHR of these 79 subjects was compared to 79 patients (control population) with normal scans (exercise = 50, adenosine = 29, male = 34, female = 45, mean age = 60 years). *Results:* The mean LHR (± SE) in subjects with normal scans was 0.30 ± 0.01. The mean LHR for those with abnormal scans and single vessel CAD who underwent exercise was 0.32 ± 0.01 and pharmacological stress was 0.31 ± 0.01. There was no statistically significant difference between the LHR of those with a normal scan and those with single vessel disease and an abnormal scan. However, there was a statistically significant association between the elevated LHR and multi-vessel CAD. The mean LHR for subjects with multi-vessel CAD with exercise was 0.39 ± 0.01 ($p = 0.000$) and for adenosine was 0.39 ± 0.02 ($p = 0.000$). *Conclusion:* An elevated LHR in patients undergoing exercise or pharmacological tc-99m MPI correlates with multi-vessel CAD.

Keywords: Stress testing; Sestamibi; Lung-to-heart ratio

1. Introduction

Exercise and pharmacological stress myocardial perfusion imaging is useful in the identification and risk stratification of CAD. Increased lung uptake of Tl-201 during exercise and pharmacological stress testing is indicative of extensive CAD and is a sign of a poor prognosis [1–4]. The LHR is derived by measuring the uptake of radioactive materials in the upper left lung and the highest counts over the myocardium in an anterior projection obtained on stress images. Even though the significance of a high lung-to-heart ratio during Tl-201 myocardial perfusion imaging is well known, the clinical significance of the LHR is not clear in tc-99m sestamibi myocardial perfusion imaging. The purpose of this study is to correlate the presence of single and multi-vessel CAD in subjects with elevated LHR.

2. Method

2.1. Patient population

A total of 530 consecutive subjects were referred to the section of cardiology at East Carolina University Brody School of Medicine over a period of 6 months for exercise or pharmacological (adenosine) myocardial perfusion imaging for evaluation of CAD. Of these, 132 had transient or partially reversible myocardial defects (ischemia or ischemia with scar). The study population is comprised of 79 of these patients who also underwent coronary

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angiography. In conjunction with myocardial perfusion imaging, pharmacological stress testing was performed in 45 patients and exercise stress testing was performed in 34 patients. Forty-three were male and 36 were female with a mean age of 61 years. The control population is comprised of 79 subjects with normal scans (no transient, partially reversible or fixed defects). Fifty of these 79 underwent exercise and 29 had pharmacological (adenosine) stress testing. Thirty-four were male and 45 were female with a mean age of 60 years. We retrospectively reviewed the myocardial perfusion scans and the coronary angiograms of these 158 total subjects.

2.2. Stress protocol

Stress testing and myocardial perfusion imaging were performed at a single location. At rest, 12–14 mCi tc-99m sestamibi was injected intravenously and the image acquisition was performed using Single Photon Emission Computer Tomography (SPECT). Exercise treadmill and pharmacological stress testing was performed using standard protocols. Maximal exercise treadmill testing was performed utilizing the standard Bruce or modified Bruce protocol with the goal of achieving at least 85% of the age predicted maximal heart rate [5]. Pharmacological stress testing was also performed (in the absence of caffeine-containing products or theophylline for 24 h) by infusing adenosine at a rate of 140 μg/kg/min for a total of 6 min. Patient symptoms, electrocardiogram, and blood pressure were recorded at baseline and continued for 5 min following the termination of stress. Forty mCi of tc-99m sestamibi was administered intravenously in the exercise group 60–90 s prior to the termination of treadmill testing and at peak effect in the pharmacological group (at the end of the third minute of adenosine infusion).

2.3. Acquisition protocol

SPECT images were acquired with a dual-head camera (DSTi; GE/SMV, Twinsburg, OH) using step-and-shoot detector rotation, obtaining 32 projections over a 180° arc (45° right anterior oblique to 45° left posterior oblique). The camera was equipped with a low energy high-resolution collimator. Rest and stress images were acquired with a 20% window centered over the 140-keV photopeak. Gated acquisitions were obtained using 8 frames per cardiac cycle with a 40% acceptance window. Acquisition times for the images were 12 and 15 min for the resting and gated stress, respectively. The gated projection datasets were pre-filtered with a Metz filter (order 3.9, cutoff of 8.0). The summed projection datasets were filtered with a Butterworth filter (order 5, cutoff of 0.33). Short, vertical long, and horizontal axis images were constructed from these projections. The images were evaluated for transient, partially reversible or fixed perfusion defects.

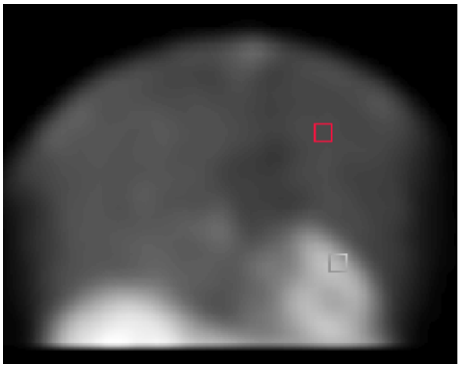

Fig. 1. A perfusion image showing one ROI over the left lung and another ROI over the myocardium.

2.4. Lung-to-heart ratio

The 32 projections of the immediate post stress (exercise or pharmacological stress) images were reviewed and the image that represented the anterior projection was chosen to calculate the LHR. The first region of interest (ROI) (5 × 5 pixel with one pixel = 6.4 mm) was placed in the upper left lung and the same size second ROI was placed on a myocardial segment having maximum count density. (Fig. 1) The LHR was calculated by dividing the counts in the left upper lung by the counts over the myocardium.

2.5. Coronary angiograms

Coronary angiograms were reviewed in the 79 patients who had transient or partially reversible myocardial perfusion defects. The number of vessels with significant CAD was recorded. Using visual estimation performed by three experienced angiographers, coronary disease was diagnosed in vessels with >50% obstruction of luminal diameter [1,6].

2.6. Statistical methods

Data was collected and stored in MS Excel worksheets, and exported to a Statistical Package for the Social Sciences (SPSS) file for analysis. Means and standard errors were used to describe the data by group, and Student's *t*-test was used to compare groups of patients, with results giving the test value, *t*, the degrees of freedom, *df*, and the *p*-value for a two sided test. A scatter plot (Graph 1) was created to illustrate the spread of values within different groups.

3. Results

In the group which underwent exercise myocardial perfusion imaging, the mean LHR (± SE) was 0.30 ± 0.01 in subjects with a normal scan, 0.32 ± 0.01 in those