CORRELATION OF GATED SPECT WITH ATTENUATION CORRECTED AND NON-ATTENUATION CORRECTED MYOCARDIAL PERFUSION SCANS

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ABSTRACT

PURPOSE: To find the correlation of Gated Single Photon Emission Tomography (SPECT) with attenuation corrected and non-attenuation myocardial perfusion scan. **METHODS:** 102 patients referred for Myocardial Perfusion Imaging (MPI); mean age: 54.6 ± 12.6, were enrolled. They all underwent stress (dynamic or pharmaceutical) and rest Tc-99m Sestamibi studies. The segmental division of left ventricle for gated and perfusion scan was done into seven myocardial regions. Correlation of non-corrected (NC) and attenuation corrected (AC) perfusion images was done with wall motion / thickening of gated SPECT. **RESULTS:** Data of 11 patients were discarded due to severe motion artifacts and / or misregistration between CT and SPECT images. Kappa value of 0.22 and 0.59 were noted when correlation between non-attenuation corrected and attenuation corrected myocardial perfusion scans and myocardial wall motions were done respectively. **CONCLUSION:** This study demonstrates that Attenuation corrected myocardial perfusion scan has moderate correlation with Gated SPECT as compared to non-attenuation corrected cardiac scan.

Key words: Myocardial perfusion imaging, Gated SPECT, Attenuation correction.

Introduction

Myocardial perfusion scintigraphy (MPS) using Single Photon Emission Tomography (SPECT) is a widely established method for the detection of coronary artery disease (CAD), diagnosis of acute myocardial infarction (MI), risk stratification and assessment of viable myocardium after infarction. However, production of image artifacts reduces the efficacy of this technique. One of the most common artifacts is soft tissue attenuation causing apparent perfusion defects. This results from absorption or redirection (scatter) of photons due to differences in tissue den-sities surrounding the heart when photons move through the body after emission from the radionuclide.[1]

This may cause an increase in false-positive studies, a decrease in the interpretive confidence of the reader and reduced diagnostic accuracy of the test leading to further diagnostic evaluations, potentially increasing the risk to the patient and the burden of healthcare expenditures.[2] Several methods have been developed to improve the recognition of soft tissue attenuation including gated SPECT and attenuation correction algorithms.[3]

Gating may help in differentiating between CAD and attenuation artifact in patients with fixed perfusion abnormalities. Normal function associated with a fixed defect on perfusion imaging can be classified as a

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soft-tissue attenuation artifact, whereas abnormal function in conjunction with a similar fixed defect would be compatible with myocardial infarction or myocardial stunning.[4,5]

However, GSPECT imaging cannot be used to differentiate between a reversible perfusion defect and artifact because the wall motion in the region with the defect would be expected to be normal in both circumstances as a result of the late acquisition of the functional data (usually about 30-60 minutes after stress depending on whether the patient had exercise or pharmacologic stress testing). Because of this limitation, ECG gating cannot be used to differentiate attenuation artifact in circumstances in which only one image is available as small infarct / scar can be missed.[5]

Recently Hybrid SPECT/CT systems are being used widely for attenuation correction (AC). Many of the recent studies have proved that CT-based AC improved specificity and diagnostic accuracy when used in conjunction with non-attenuation-corrected images.[3]

The aim of the present study were to find correlation between gated SPECT with non attenuation corrected and attenuation corrected image sets in myocardial perfusion SPECT.

Material and Methods

We studied a group of 102 patients, 66 males and 36 females who had been referred to our department with diagnostic as well as risk stratification purposes as part of their clinical management. Patients with MI, LBBB, and history of revascularization or cardiomyopathies were excluded from the study.

Preparation of Patient

Patients were studied after a 4hours fasting period and they were advised to refrain from tea, coffee, chocolate cola drinks at least 12 h before stress. Beta-blockers were discontinued for 72 h, calcium channel blockers for 48-72 h and long acting nitrates for 12 h before the study. Physical examination and baseline ECG were done and IV line was maintained.

Protocols of the Study

Dynamic stress Patients underwent symptom-limited Exercise Tolerance Test (ETT) on treadmill following standard Bruce or modified Bruce protocol to achieve an adequate workload (at least 85% of age-adjusted maximal predicted heart rate). At peak exercise, 10 mCi of Tc-99m Sestamibi was injected as a bolus into the intravenous line and flushed with 5 ml of NaCl 0.9% solution. Exercise was continued at the same level or at a lower level for next 60 sec.

Patients who were unable to perform treadmill test in order to achieve target heart rate were infused intravenously with Dipyridamole at a dose of 0.56 mg/kg intravenously over 4-minute period (142 mcg/kg/min). 3 min after pharmacological stress, 10 mCi of Tc-99m Sestamibi was injected. Intravenous aminophylline (75-250 mg) was administered routinely to every patient to reverse the effects of dipyridamole.

Imaging Protocol

One day imaging protocol was followed for the study population. Patients were instructed to take a fatty meal immediately after the end of the stress to accelerate tracer clearance from the liver and gallbladder. Imaging commenced 45 min post injection. The second injected dose was 30 mCi for the rest imaging, approximately thrice the stress dose in order to overwhelm the activity remaining in the myocardium. It followed the first by 3 hours to permit time for some decay of the agent. Rest images were then obtained.

Acquisition Parameters

The patients were required to lie supine on the scintibed with arms extending above the head. The position assured proper exposure of the heart to the camera. Patients were instructed to restrict the movements or cough during acquisition.

SPECT images were acquired using rotating large field of view gamma camera Infinia Hawkeye equipped with two detectors positioned at 90 degree (L mode) and low energy high resolution parallel hole collimator connected to dedicated computer system. Using step and shoot method, a total 64 frames each of 40 seconds were acquired in continuous acquisition mode over 180 degrees, anteriorly in a circular arc, with a starting angle of 45 degrees right anterior oblique (RAO) position to the 135 degrees left pos-terior oblique position. A 20% symmetric energy window centered at 140 keV

was used. A zoom of 1.33 was applied during acquisition. All projection images were stored on magnetic disc by means of 64 X 64-word matrix. Total study duration was 20 minutes.
The hybrid camera uses a low dose CT (140 kVp, 2.5 mA) for attenuation correction at the end of study without changing the position of the patient or without intravenous contrast material and without a breath-hold.

ECG Gating: R wave triggered the cardiac cycle. Gating was performed with a 40% acceptance window to maximize detected events in the non gated perfusion data. Sixteen frames per cardiac cycle were acquired. On the camera, rejected beats are stored separately and contribute to the summed (non- gated) dataset to improve count statistics.

Reconstruction Protocol

Before reconstruction, the projection data were reviewed in cine mode to rule out the possibility of patient motion. For SPECT image reconstruction, all data was transferred on GE Xeleris nuclear medicine work station. Using the 180-degree iterative reconstruction transverse reconstruction was done. Each slice was 2.2 mm thick (1 pixel); three slices were added together using Myovation software during reformatting into short axis, vertical long axis (VLA) and horizontal long axis (HLA). The attenuation corrected and non corrected slices were generated.

Data Analysis

All the studies were assessed for any mal-registration and patient movement. If there was slight misregistration between emission and transmission data, the images were reprocessed but discarded if there was evidence of significant patient motion or misregistration during acquisition.
Cardiac scans were assessed visually by 2 experienced nuclear physicians. Stress and rest tomograms were presented in a random sequence for interpretation to experienced observers. During visual interpretation, no clinical information was taken into account, such as patient history and CAG findings. The experts were also blinded to any computer generated myocardial perfusion scores or patient group information. However, all available image data including raw projections rest and stress NC and AC scans were considered during interpre-tation. The observers interpreted the both images sets (non corrected and attenuation corrected) by rating each segment as normal or abnormal with a reversible or a fixed perfusion defect on short axis and long axis slices as well as the polar map. A third expert was called in when there was disagreement between the two experienced nuclear physicians.
A reversible perfusion defect was defined as a perfusion defect on stress images that partially or completely resolved at rest in two or more contiguous segments or slices. A fixed perfusion defect was defined as a perfusion defect on stress images in two or more contiguous segments or slices that persisted on rest images. An abnormal study was defined as on demonstrating a fixed or reversible perfusion defect.
A systemic approach for the display and interpretation of the ventricular function derived from gated SPECT was employed. The ejection fraction, end diastolic, end systolic and stroke volumes were noted in due course. Regional wall motion was perceived visually as a displacement of the myocardial wall inward during systole and assigned as being normal, hypokinetic, dyskinetic and akinetic while the regional wall thickening was assessed for its presence or absence. The segmental division of left ventricle was grouped to seven myocardial regions i.e. an anterior, anteroseptal, inferoseptal, inferior, inferolateral, anterolateral, and apical region for sake of ease in order to compare them with the segments of perfusion scan.

Statistical Analysis

All continuous data like age had been presented as the mean standard deviation while categorical data was presented as percentages. The agreement between gated wall motion/thickening with NC and AC perfusion scans were quantified with Cohen's kappa.

Results

In this prospective study, data of 11 patients (4 female and 7 males) were discarded due to severe motion artifacts and / or misregistration between CT and SPECT images.

There were 91 patients; their mean age was 53.24 ± 12.7 years, with a range of 30-78 years and mean height was 162.0 ± 25.18 cm. The study population had mean weight of 72.70 ± 15.56 kg.
Summary of the demographic data is shown in (Tab. 1).

	Population
n	91
Age	53.24±12.7
Female	32 (35%)
Male	59 (65%)
Hypertension	55 (60%)
Diabetes	23 (25%)
Family History	29 (32%)
Hyperlipidemia	17 (18%)
Smoking	28 (19%)
End diastolic volume	67.48±25.90
End systolic volume	23.96±20.55
Stroke volume	44.92±10.31
Ejection fraction	71.19±16.18

Table 1: Demographics of the study population.

Correlation of Myocardial Perfusion with Myocardial Wall Motion and Thickening

Of the 637 segments analyzed with NC images, 585 (71%) regions had normal wall motion and thickening and 34 (5%) regions had abnormal wall motion or thickening. There was a weak agreement in the regional score between myocardial perfusion and myocardial wall motion: (77%) 492/637 for gated SPECT. Of the 52 regions that had abnormal wall motion or thickening, 18 (35%) regions show normal or inducible ischemia on gated SPECT (Tab. 2).
Of the 637 segments analyzed with AC images, 585 (71%) regions had normal wall motion and thickening and 29 (4%) regions had abnormal wall motion or thickening. There was a moderate agreement in regional score between myocardial perfusion and myocardial wall motion: (95%) 602/637 for gated SPECT. Of the 52 regions that had abnormal wall motion or thickening, 23 (44%) regions show normal or inducible ischemia on gated SPECT (Tab. 3).

	Fixed perfusion defects	Normal perfusion or inducible ischemia	Total
Normal wall motion or thickening	127	458	585
Abnormal wall motion and thickening	34	18	52
Total	161	476	637
Kappa value	0.22		

Table 2: Regional score agreement on NC images between myocardial perfusion and myocardial wall motion and thickening by gated SPECT

	Fixed perfusion defects	Normal perfusion or inducible ischemia	Total
Normal wall motion or thickening	12	573	585
Abnormal wall motion and thickening	29	23	52
Total	41	596	637
Kappa value	0.59		

Table 3: Regional score agreement on AC images between myocardial perfusion and myocardial wall motion and thickening by gated SPECT

Discussion

According to previous studies, by inspecting resting wall motion / thickening, a nuclear physician may differentiate true fixed perfusion defects from artifacts. If resting wall motions / thickening are normal, then perfusion in that segment is considered normal and the apparent perfusion decrease at rest is an artifact.[4] If decreased uptake during stress is similar to that seen during the resting period and that segment shows good wall motion or thickening, the apparent hypo perfusion during stress is also an artifact. However, when decreased uptake is found only during a period of stress, or when it is necessary to differentiate a reversible decrease from an artifact, gated SPECT is of little value.[6] In such cases attenuation correction may be helpful.
The benefits of CT based attenuation correction are less noise, faster acquisition, no influence of the SPECT radionuclide on CT data and no need to replace decayed transmission source.[7] Hendel et al reported that the use of attenuation correction may improve the diagnostic accuracy of MPI, particularly with regard to its specificity. In addition, it may save time and reduce costs in stress laboratories by allowing them to perform stress only perfusion imaging in patients with a low to intermediate risk of CAD, with greater reader confidence and accuracy.[8]
We tried to validate our attenuation correction effect

by finding the correlation of NC and AC perfusion images with gated wall motion and/or wall thickening analysis. We found a weak agreement in the regional score between myocardial perfusion and myocardial wall motion (k=0.22) for gated SPECT, since there had been many artifactual perfusion defects in NC images that did not correlate with regional wall motion or thickening. Conversely, there was a moderate agreement in regional score between myocardial perfusion and myocardial wall motion (k=0.59) for gated SPECT as many of the artifactual (due to attenuation) perfusion defects reduced in attenuation corrected images.

As wall thickening is more accurate than gated SPECT wall motion analysis,[9] we included both i.e. wall motion as well as thickening in our criteria for finding correlation with perfusion analysis. Despite this, on AC study there were 12 regions which showed fixed perfusion defects but normal wall motion or thickening, this could be due to either small or a non transmural infarct in the region. 23 regions on AC were those which had abnormal wall motion / thickening but normal perfusion or inducible ischemia. This effect was probably due to partial-volume effect of thin infarcted area causing overestimation of impaired wall thickening. Another possibility is non-visualization of regional wall due to severe attenuation as gated images were obtained by filtered back projections. Furthermore, we assessed correlation on visual analysis, and therefore, it is needless to say that were probabilities of human errors in making judgments.

There are many studies which proved that ECG gating provide additive value to the SPECT diagnostic accuracy.[10,11] Gating is particularly helpful in cases where the non-AC or AC images are uninterpretable due to artifacts from high tracer activity in adjacent abdominal viscera. The other category where adding gating proved beneficial is in the case of balanced three-vessel disease. In this situation, which is rare, regional myocardial uptake throughout the heart is normalized to the region of greatest uptake and it is assumed that the region with the greatest imaged activity has normal myocardial perfusion. However, in three vessel disease, the area of myocardium with highest uptake may not represent normally perfused myocardium which can be clarified by impairment in wall thickening and motion. In addition, gated SPECT provides information on left ventricular wall motion, thickening, left ventricular cavity volume and ejection fraction, which provide additional prognostic information.[12]

Conclusion

Gating provides modest correlation with attenuation corrected myocardial perfusion scan as compared to non-attenuation corrected images, signifying the importance of attenuation correction. Furthermore, gated SPECT also provides information on left ventricular cavity volume and ejection fraction. Therefore, both gated and attenuation correction should be used in combination.

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