Assessment of Myocardial Viability in Patients with Left Ventricular Dysfunction:Correlation between CT-Based Attenuation Correction and Uncorrected Quantification Analysis in Thallium201(^{201}Tl)Rest-Redistribution SPECT Study

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Abstract

Objectives: Previous studies have demonstrated that Quantitative Rest-Redistribution Thallium Imaging is one of the most accurate protocols for the assessment of myocardial viability. This study was conducted to evaluate the alteration of the relative segmental activity of quantification analysis in patients undergoing theRest-Redistribution Thallium-201 Study via theSingle Photon Emission Computed Tomography(SPECT) method for the assessment of viability before(NC)and after introducing CT-based attenuation correction (CTAC).

Materials and Methods: Forty-two patients with left ventricular dysfunction who were referred for viability assessment with Thallium-201 Rest-Redistribution protocol were included. A series of two acquisitions, comprising twenty-minute rest and four-hour redistribution acquisitions, were performed for all the patients. CT acquisition of the same region of the SPECT acquisition was performed for attenuation correction, immediately after the completion of each SPECT study. All the images were analyzed quantitatively to obtain normalized segmental activity on the basis of seventeen-segment model.

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Results: Forty-two patients (9 women and 33 men) at a mean age of 64 ± 12.2 years and a mean ejection fraction (EF) of 24.4 ± 10.1% were recruited in the study. There was a significant agreement between the NC and CTAC images in the apex, apical anterior, apical septum, apical lateral, mid anterior, mid inferoseptal, mid anterolateral, basal anterior, basal anteroseptal, basal inferoseptal, basal inferolateral, and basal anterolateral segments between the two methods (p value <0.05) for predicting viability. However, no significant agreement was noted in the apical inferior, mid anteroseptal, mid inferior, mid inferolateral, and basal inferior segments.

Conclusion: The results of the present study suggest that CT-based attenuation correction can play a role in minimizing the patient's body-related attenuation artifact, resulting in a different quantification result in a Rest-Redistribution Thallium-201 Viability study, particularly in the territory of the right coronary artery. ***(Iranian Heart Journal 2013; 13(4):15-20).***

Keywords: Nuclear medicine ■ Viability ■ Thallium 201 ■ redistribution ■ Myocardial infarction ■ Attenuation correction

Introduction

Noninvasive assessment of myocardial viability, including myocardial perfusion imaging (MPI) by the Single Photon Emission Computed Tomography (SPECT) method with thallium-201, plays an important role in selecting the appropriate treatment strategy and predicting the clinical benefits of revascularization in patients with coronary artery disease and left ventricular dysfunction.[1,2]

It has been shown that the Rest-Redistribution Thallium-201 SPECT Study has an excellent sensitivity for predicting myocardial viability after myocardial infarction.[3] In most of the studies, regional thallium activity was analyzed quantitatively in order to assess regional viability.[4] However, one of the most prevalent artifacts in MPI is caused by the patient's body-related attenuation of photons,[5] which can have a potential effect on the accuracy of segmental quantification. The accuracy of SPECT MPI has been substantially improved owing to the utilization of attenuation correction over the last decade.[6]The added value of CT-based attenuation correction (CTAC) has been also well established on the overall diagnostic performance of SPECT MPI.[7]

In this study, we evaluated the difference in the interpretation of SPECT MPI segmental quantitative results in patients undergoing viability assessment, using the Rest-Redistribution Thallium-201 Study before and after the introduction of CTAC.

Material and Methods

This study included 42 patients (33 men, 9 women, aged 46-70 years) with left ventricular dysfunction who were referred to our department for viability assessment between June 2011 and April 2012. All the patients underwent the Rest-Redistribution Protocol, using Thallium-201 with an injection dose of 130 MBq. A series of two acquisitions, comprised of twenty-minute rest and four-hour redistribution acquisitions, were performed for all the patients. SPECT acquisitions were performed in the step-and-shoot mode with 60 twenty-second projections, a zoom factor of 1.5, and a 64×64 matrix size in a non-circular 180° arc (45° right anterior oblique to left posterior oblique) by an Infinia Hawkeye 4 dual-head SPECT/CT camera (GE Healthcare, USA), equipped with low energy-high resolution (LEHR) collimators. CT acquisition of the same region of the SPECT acquisition was performed for AC purpose, immediately after the completion of each SPECT study, using 2.5 mA tube current and peak voltage of 140 kVp (set as default). All the data were reconstructed with ordered subset expectation maximization (OSEM), using two iterations and ten subsets. The quality control of the rotating raw images and SPECT/CT registration of all the patients was performed, and studies with motion artifacts, interfering extracardiac activity or SPECT/CT misregistration were excluded.

The reconstructed and reoriented images of both uncorrected (NC) and CT-based corrected for attenuation were then analyzed further, using the 4DMSPECT 4.0 software for cardiac quantification. All the images were analyzed quantitatively to obtain normalized segmental activity on the basis of seventeen-segment model. All segments with a relative activity of at least 50% in either rest or redistribution images or reversibility of 10% or greater between the rest and reversibility images were considered as viable segments.

Statistics

The chi-squared test was used for the categorical, and the Student *t*-test and Mann-Whitney U test were employed for the numerical variables. Multivariate logistic regression models were also drawn upon to investigate adjusted associations between the variables.

The data are described as mean ± standard deviation (SD) and as count (%) for the interval and categorical variables, respectively. A p value<0.05 was considered statistically significant.

The data were managed and analyzed using Statistical Program for Social Sciences (SPSS 15.0 for Windows, SPSS Inc. Chicago, Illinois). Stata 8 SE for Windows (Stata Corporation, Texas, USA) was also used for statistical modeling.

Results

Forty-two patients (9 women and 33 men) at a mean age of 64 ± 12.2 years and a mean ejection fraction of 24.4 ± 10.1% were recruited in the study. The background demographic and descriptive data are listed in Table 1.

Based on kappa statistics, there was a significant agreement between the NC and CTAC images in the apex, apical anterior, apical septum, apical lateral, mid anterior, mid inferoseptal, mid anterolateral, basal anterior, basal anteroseptal, basal inferoseptal, basal inferolateral, and basal anterolateral segments between the two methods (p value <0.05) for predicting viability. In these segments, the highest kappa was related to the mid anterior segment (kappa = 0.788) and the lowest kappa was related to the basal inferoseptal segment (kappa = 0.226). However, no significant agreement was noted in theapical inferior, mid anteroseptal, mid inferior, mid inferolateral, and basal inferior segment.

Comparison of male and female relative segmental activity demonstrated a significant agreement in the apical septum, mid anterior, and basal anteroseptal segments between the two methods in the women. Nonetheless, no significant agreement existed between the two methods in the other segments. On the other hand, except for the apical inferior, the mid anteroseptal, mid inferior, mid inferolateral, and basal inferior segments, there was a significant agreement for the other segments between the NC and CTAC imaging in the men.

A sample image of rest and redistribution SPECT images as well as polar maps with relative segmental activity before and after CTAC is shown in Figure 1.

Table 1 – Background and demographic descriptive data (n = 42)

Characteristic/Variable	Mean ± SD/ count (%)
Age (year)	64 ± 12.2
Gender (F/M)	9/33
Ejection fraction (%)	24.4 ± 10.1
Risk Factors	
Diabetes	17(42.5)
Hypertension	10(25)
Hypercholesterolemia	11(27.5)
Family History	4(10)
Smoking	6(15)

Statistics are numbers (%) or mean ± standard deviation

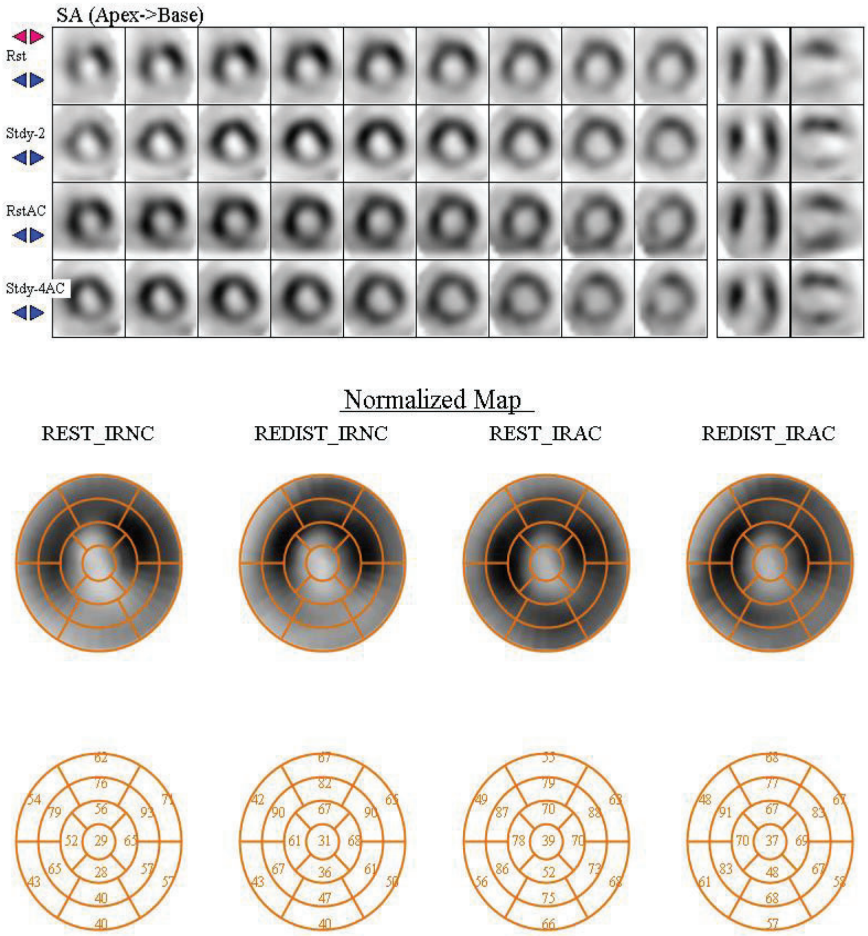

Figure 1-A sample image of the Rest and Redistribution SPECT images as well as polar maps with relative segmental activity before and after attenuation correction.

Discussion

In patients with coronary artery disease and left ventricular dysfunction, noninvasive assessment of myocardial viability plays a pivotal role in the clinical decision-making process.[8]Quantitative Thallium-201 Rest-Redistribution Imaging,a method for viability assessment, can predict regional left ventricular functional recovery with accuracy comparable to that of Positron Emission Tomography (PET) imaging with 18F fluorodeoxyglucose (FDG).[4]

One of the most prevalent artifacts in MPI is related to the attenuation of photons by an individual's body. A large body habitus can lead to less diagnostic images as a result of generalized count decrease and creation of noisier images.[5]Several methods are currently available for attenuation correction. Along with the development of combined SPECT and CT hybrid cameras, high-count and high-resolution transmission maps can be generated in a short length of time.[6]

Previous data suggested that attenuation-corrected MPI images provided higher left ventricular count homogeneity in healthy patients, facilitating the interpretation of these studies and, therefore, resulting in improved diagnostic accuracy.[9]

To the best knowledge of the authors, this is the first study of its kind to implicate quantification results before and after CTAC for the assessment of viability. The results of our study show that the correction of attenuation artifacts, using a hybrid camera, can alter the value of relative segmental activity and, thus, alter the result of viability assessment, especially in the right coronary artery territory. Gender-based analysis revealed more extensive changes in relative segmental activity between the two methods in the women, which is probably related to the attenuation effect of the breast and the overlying chest wall soft tissue. Be that as it may, we found that alteration in relative segmental activity was more prominent in the inferior wall (right coronary artery territory) in the men, which is probably related to a more prominent diaphragmatic attenuation effect in this group. Such changes may be important in the assessment of relative segmental activity and, therefore, predict viability via quantification methods.

Limitations

The aim of this study was to evaluate the effect of attenuation correction on the value of relative segmental activity in Rest-Redistribution 201-thallium Viability Study. Nonetheless, one of the main goals of a viability study is to predict the functional recovery after revascularization. Therefore, on the basis of our findings, there is a need for additional study to correlate the amount of functional recovery after revascularization with the results of CT-based attenuation corrected relative segmental activity in interpretation of the Rest-Redistribution Thallium-201 Viability Study.

Conclusion

CTAC can play a role in minimizing the patient's body-related attenuation artifact, conferring a different quantification result in the Rest-Redistribution Thallium-201 Viability Study, particularly in the territory of the right coronary artery in men.

References

1- Allman KC, Shaw LJ, Hachamovitch R, Udelson JE. Myocardial viability testing and impact of revascularization on prognosis in patients with coronary artery disease and left ventricular dysfunction: a meta-analysis. *J Am CollCardiol*. Apr 3 2002;39(7):1151-1158.

2- Gioia G, Milan E, Giubbini R, DePace N, Heo J, Iskandrian AS. Prognostic value of tomographic rest-redistribution thallium 201 imaging in medically treated patients with coronary artery disease and left ventricular dysfunction. *J NuclCardiol*. Mar-Apr 1996;3(2):150-156.

3- Coll C, Gonzalez P, Massardo T, et al. Performance of Thallium 201 rest-redistribution spect to predict viability in recent myocardial infarction. *Rev Med Chil*. Mar 2002;130(3):243-250.

4- Holly TA, Bonow EO. Assessment of Myoocardial Viability with Thallium-201 and Technetium-Based Agents.In: Zaret BL, Beller GA. *Clinical Nuclear Cardiology, State of the Art and Future Directions*.4th ed, Mosby Elsevier, 2010: 594-607

5- Burrell S, MacDonald A. Artifacts and pitfalls in myocardial perfusion imaging.*J Nucl Med Technol.* 2006 Dec;34(4):193-211

6- Fricke E, Fricke H, Weise R, Kammeier A, Hagedorn R, Lotz N, et al. Attenuation correction of myocardial SPECT perfusion images with low-dose CT: Evaluation of the method by comparison with perfusion PET. *J Nucl Med.* 2005 May;46(5):736-44.

7-Masood Y, Liu YH, Depuey G, Taillefer R, Araujo LI, Allen S, et al. Clinical validation of SPECT attenuation cor rection using x-ray computed tomography-derived attenuation maps: multicenter clinical trial with angiographic correlation. *J NuclCardiol.* 2005 Nov-Dec;12(6):676-86.

8-Cucolo A, Acampa W, Nicolai Emanuele, Pace L, Petretta M, Salvatore M.Quantitative thallium-201 and technetium 99m sestamibi tomography at rest in detection of myocardial viability in patients with chronic ischemic left ventricular dysfunction. *J NuclCardiol* 2000 February;7(1):8-15.

9-Pazhenkottil AP, Ghadri J, Nkoulou N, Wolfrum M, Buechel R, Kuest SM, et al. Improved Outcome Prediction by SPECT Myocardial Perfusion Imaging After CT Attenuation Correction. *J Nucl Med* 2011 February;52(2):196–200.