

Different Aspects of Transient Ischemic Dilation

Vahid Reza Dabbagh Kakhki, M.D.

Department of Nuclear Medicine, Imam Reza Hospital,
Mashhad University of Medical Sciences, Mashhad, Iran.

(Received 20 July 2007, Revised 15 September 2007, Accepted 5 October 2007)

ABSTRACT

Transient ischemic left ventricular dilation (TID) is a marker of severe and extensive coronary artery disease as well as an increased risk of adverse outcomes. The patients with more severe and extensive ischemia, multivessel-type of perfusion abnormality as well as patients with left anterior descending artery (LAD) territory perfusion abnormality have more probability of having TID. Evaluation of TID may be purely visual, or based on calculation of TID ratio between stress and rest images. Cutoff values for an abnormal TID ratio vary widely throughout the literature and may be related to different factors like patient populations and imaging protocols. On the other hand, several other causes of TID in the absence of significant epicardial stenoses have been reported. These include severe hypertension with myocardial hypertrophy; hypertrophic cardiomyopathy; and dilated cardiomyopathy.

Key Words: Transient ischemic dilation, Myocardial perfusion SPECT, Ischemia.

Iran J Nucl Med 2007; 15(2): 30-33

Corresponding Author: Dr Vahid Reza Dabbagh Kakhki, Department of Nuclear Medicine, Imam Reza Hospital, Mashhad University of Medical Sciences, Mashhad, IRAN.
E-mail: dabbaghvr@mums.ac.ir

Transient ischemic left ventricular dilation (TID) refers to a significant enlargement in left ventricular (LV) size on the stress myocardial perfusion imaging (MPI) as compared with the rest images (1). Although implementation of nonperfusion parameters such as TID may improve the diagnostic accuracy of myocardial perfusion SPECT(MPS), the principal added value of TID is that it is a marker of severe and extensive coronary artery disease (CAD) as well as an increased risk of adverse outcomes (2). TID ratio was significantly correlated with the extent and severity of stress-induced perfusion abnormality, thus

higher TID ratio suggesting a greater ischemic burden. The patients with more severe and extensive ischemia, multivessel-type of perfusion abnormality as well as patients with left anterior descending artery (LAD) territory perfusion abnormality had more probability of having TID (1,3). Abidov et al.(4) reported that an abnormal TID ratio had high sensitivity and specificity (71% and 87% respectively) for severe and extensive coronary artery disease ($\geq 90\%$ stenosis involving either the proximal LAD or ≥ 2 coronary vessels). In addition, multivariate logistic regression analysis showed that the presence of ischemia and LAD territory perfusion

abnormalities were independent predictors of TID (3).

The underlying mechanisms of TID include: 1- the presence of myocardial stunning as a possible cause of a true increase in LV size after exercise- or pharmacologically-induced ischemia ,2- a pseudo-dilatation effect due to diffuse subendocardial ischemia (3,5).

Evaluation of TID may be purely visual, or based on calculation of TID ratio between stress and rest images. Manual or automatic definition of the myocardial wall boundary is possible (epicardial or endocardial LV edges) in non-gated images to calculate TID ratio (3,6). There are few semi-automatic measures and automatic practical algorithms for the quantification of the TID ratio. QPS (Quantitative Perfusion SPECT, Cedars Sinai Medical Center) and ECTb (Emory Cardiac Toolbox) are two current automatic methods which calculated endocardial volumes of the LV from 3-dimensional images (1,3,4,7,8). Recently Heston et al.(9) reported that by calculation of end-systolic (ESV) and end-diastolic(EDV) volumes using gated images, the relative contributions of each to the TID ratio may be estimated. Thus they suggested that TID ratio could be estimated by the ratio of Stress $(ESV \times 5 + EDV) / Rest(ESV \times 5 + EDV)$. However, totally automatic method for assessing TID ratio may eliminate subjectivity and observer variability (3).

TID can be observed after exercise or pharmacological stress using stress/redistribution TI-201, dual isotope and single day or 2-day Tc99m-tracers MPS (3). However, the important issue is to determine the cut-off value for an abnormal TID ratio. It has been well documented that cutoff values for an abnormal TID ratio vary widely throughout the literature, ranging from 1.012 to 1.40 (3-5, 9,10). Also, the frequency of abnormal TID ratio on radionuclide MPS reported to range from 8% to 37% (1). Knowledge of this variation is important while interpreting MPS studies. Table 1 shows different thresholds for TID ratio in the published literature. Part of variability in assessment of TID ratio arises from the different patient populations, protocols, stress modalities, use of different isotopes for rest and/or stress studies, time to imaging after stress, different types of stress, differences in the image matrix, zoom, slice selection, or injected dose of radionuclide between the rest and stress studies(one-day Tc99m-tracers protocol)(1,3,4,8-17).

We already derived abnormal threshold for automatically measured TID ratio in 2-day dipyridamole ^{99m}Tc-sestamibi MPS that was >1.19 with a frequency of 11.6% abnormal TID ratio (3).

Hung et al. (1) reported that 26% of patients undergoing dipyridamole TI-201 stress-redistribution MPS had abnormal TID ratio. Although dynamic exercise and dobutamine tests are considered to be the procedures with most capability of provoking myocardial ischemia and stunning, dipyridamole, and adenosine- induced myocardial stunning are also demonstrated (18-20). However, MPS via TI-201 allows an earlier scanning after stress than Tc99m-tracers by pharmacological stress and may be more suitable for detecting stress-induced functional changes, such as ischemic stunning(1). Thus, this earlier start is likely to have increased the frequency of observing TID. In this regard, patients with TID on vasodilator stress MPS had a more than 4 times greater incidence of myocardial stunning (defined as poststress decrease in LV ejection fraction >6%) (1). Dual isotope sequential rest TI-201/stress Tc-99m tracers could show normal variability in cavity size of up to 20% as a result of differences in image resolution of the two radionuclides (14). The TID ratio threshold is higher for dual-isotope TI-201/Tc-99m procedures, in which the increased scatter associated with the lower-energy TI-201 has the result of causing the myocardium to appear thicker and the LV cavity smaller (2,3). Probably there is difference in normal range of TID ratio between males and females (3). Rivero et al. (7) found that female patients showed higher mean TID ratio than male patients. Possible explanations for the gender differences may be merely a technical bias created by smaller absolute LV volumes in women. Another possible explanation is that women usually are less physically conditioned than men. This may cause women's hearts to dilate more during stress when compared with male hearts as a compensatory mechanism (3,7).

The threshold for abnormal TID ratio is higher with vasodilator stress than exercise stress (21). A 2-day technetium 99m protocol, in which the injected dose, the count statistics, and the filtering are the same on both phases, will result in a lower threshold for TID ratio than protocols in which the doses, filters, or radioisotopes used are different(21). The lowest threshold for abnormality would be expected in men with exercise stress and 2-day high-dose Tc-99m studies and the highest threshold would be expected in women undergoing a dual-isotope protocol with adenosine stress. No single cutoff for abnormal TID ratio fits all patients, protocols, and stress types (21). Some patients with normal tomograms revealed an abnormal TID ratio. However, some observers have reported a subgroup of patients with significant epicardial disease on angiography that shows TID in

the absence of reversible defects (3). Severe multivessel disease producing global ischemia with uniform perfusion ("balanced ischemia") is the generally accepted explanation (14). In such cases, TID could be a very useful scan indicator of severe underlying CAD. However, cautious scan interpretation is required whenever TID is associated with uniform perfusion because there is a high incidence of noncoronary causes and technical artifacts (3,14,22). It is well documented that significant epicardial atheromatous disease could be present even if there is no angiographic evidence of disease. This has been convincingly shown by intravascular ultrasound in the presence of diffuse disease and arterial remodeling. Several other causes of TID in the absence of significant epicardial stenoses have been reported. These include severe hypertension with myocardial hypertrophy; hypertrophic cardiomyopathy; and dilated cardiomyopathy(3,14,22). Reduced coronary flow reserve has been reported in these patients (3). Also small left ventricles could be more prone to elevated TID ratios for technical reasons (1).

It is suggested that TID is predictive of proximal left anterior descending arteries or multiple vessels disease (1,3). An entirely normal stress MPS study does not always imply an excellent prognosis. TID is also an independent and incremental adverse prognostic predictor in patients undergoing MPS. TID occurring in the absence of perfusion defects was associated with a worse prognosis than otherwise attributed to patients with normal SPECT MPI and no TID (21).

When TID is seen without perfusion defects, the interpreting physician should carefully scrutinize all of the available clinical and stress test data for other signs of ischemia to identify patients in whom it might be appropriate to test further for possible extensive CAD. For example if the TID in "normal" perfusion MPS is associated with post-stress stunning, as manifested by new regional wall motion abnormalities, it is more likely that the patient has severe CAD as a cause of TID and catheterization may be appropriate(2).

Finally, Abidov et al. (21) suggested that the interpreting physician should be cognizant of the fact that the cutoff value for TID is different for different MPS protocols; any published TID ratio threshold thus far is a protocol-specific value and should not be directly extrapolated to all patients undergoing MPS (21).

References

1. Hung GU, Lee KW, Chen CP, Lin WY, Yang KT. Relationship of transient ischemic dilation in dipyridamole myocardial perfusion imaging and stress-induced changes of functional parameters evaluated by Tl-201 gated SPECT. *J Nucl Cardiol.* 2005; 12:268-75.
2. Abidov A, Berman DS. Transient ischemic dilation associated with poststress myocardial stunning of the left ventricle in vasodilator stress myocardial perfusion SPECT: True marker of severe ischemia? [editorial]. *J Nucl Cardiol.* 2005;12:258-60.
3. Kakhki VR, Sadeghi R, Zakavi SR. Assessment of transient left ventricular dilation ratio via 2-day dipyridamole Tc-99m sestamibi nongated myocardial perfusion imaging. *J Nucl Cardiol.* 2007; 14: 529-36
4. Abidov A, Bax JJ, Hayes SW, Cohen I, Nishina H, Yoda S, et al. Integration of automatically measured transient ischemic dilation ratio into interpretation of adenosine stress myocardial perfusion SPECT for detection of severe and extensive CAD. *J Nucl Med.* 2004; 45:1999-2007.
5. Iskandrian A, Jaekyeong H, Thach N, Lyons E, Paugh E. Left ventricular dilation and pulmonary thallium uptake after single photon emission computed tomography using thallium-201 during adenosine induced coronary hyperemia. *Am J Cardiol.* 1990; 66: 807-11.
6. Peace RA, Mckiddie FI, Staff RT, Gemmill HG. Comparison of methods for quantification of transient ischaemic dilation in myocardial perfusion SPET. *Nucl Med Commun.* 2000; 21: 971-6
7. Rivero A, Santana C, Folks RD, Esteves F, Verdes L, Esiashvili S. Attenuation correction reveals gender-related differences in the normal values of transient ischemic dilation index in rest-exercise stress sestamibi myocardial perfusion imaging. *J Nucl Cardiol.* 2006; 13:338-44.
8. Kakhki VD, Zakavi SR, Sadeghi R. Comparison of two software in gated myocardial perfusion single photon emission tomography, for the measurement of left ventricular volumes and ejection fraction, in patients with and without perfusion defects. *Hell J Nucl Med.* 2007; 10: 19-23

9. Heston TF, Sigg DM. Quantifying transient ischemic dilatation using gated SPECT. *J Nucl Med.* 2005; 46:1990-6.
10. Williams K, Schnieder C. Transient ischemic dilatation (TID) with pharmacological stress dual isotope SPECT [abstract]. *Circulation.* 2000;102:II-546.
11. Mazzanti M, Germano G, Kiat H, Kavanagh PB, Alexanderson E, Friedman JD, et al. Identification of severe and extensive coronary artery disease by automatic measurement of transient ischemic dilatation of the left ventricle in dual-isotope myocardial perfusion SPECT. *J Am Coll Cardiol.* 1996; 27:1612-20.
12. Sugihara H, Shiga K, Umamoto I, Harada Y, Katahira T, Nakagawa T, et al. Assessment of transient dilatation of the left ventricular cavity in patients with hypertrophic cardiomyopathy by exercise thallium-201 scintigraphy. *Kaku Igaku.* 1990;27:1281-9.
13. Kritzman JN, Ficaro EP, Corbett JR. Post-stress LV dilatation: the effect of imaging protocol, gender and attenuation correction [abstract]. *J Nucl Med.* 2001;42:50P.
14. Choong KKL, Russell PA. Transient left ventricular dilatation in the absence of epicardial disease on angiography. *Clin Nucl Med.* 2004; 29:348-51.
15. Kakhki VD, Zakavi SR, Bakhtiari H. Effect of Patient Positioning on Left ventricular volumes and Function During Gated Tc-99m Sestamibi myocardial perfusion SPECT: Comparison between the results obtained in Prone and Supine positions. *World J Nucl Med.* 2006;5:9-12.
16. Kakhki VD, Sadeghi R. Gated myocardial perfusion SPECT in patients with a small heart: effect of zooming and filtering. *Clin Nucl Med.* 2007; 32:404-6.
17. Zakavi SR, Zonoozi A, Kakhki VD, Hajizadeh M, Momennezhad M, Ariana K. Image reconstruction using filtered backprojection and iterative method: effect on motion artifacts in myocardial perfusion SPECT. *J Nucl Med Technol.* 2006; 34: 220-3.
18. Kakhki VD, Zakavi SR, Sadeghi R, Yousefi A. Importance of gated imaging in both phases of myocardial perfusion SPECT: Myocardial stunning after dipyridamole infusion. *J Nucl Med Technol.* 2006;34: 88-91.
19. Kakhki VD, Jabari H. Dipyridamole stress and rest gated ^{99m}Tc-sestamibi myocardial perfusion SPECT: left ventricular function indices and myocardial perfusion findings. *Iran J Nucl Med.* 2007; 15:1-7
20. Dakik HA, Alam S. Myocardial stunning induced and detected by adenosine stress perfusion imaging. *J Nucl Cardiol.* 2001; 8:711-2.
21. Abidov A, Germano G, Berman DS. Transient ischemic dilatation ratio: A universal high-risk diagnostic marker in myocardial perfusion imaging. *J Nucl Cardiol.* 2007; 14: 497-500.
22. Robinson VJ, Corley JH, Marks DS, Eberhardt LW, Eubig C, Burke GJ, et al. Causes of transient dilatation of the left ventricle during myocardial perfusion imaging. *AJR Am J Roentgenol.* 2000;174: 1349-52.