Myocardial perfusion image findings in apical hypertrophic cardiomyopathy

Bill P. C. Hsieh, MD, and Mark I. Travin, MD

Case Presentations. *Patient #1* A 48 year-old female with hypertension and hypercholesterolemia, but without previous cardiac history, was hospitalized with 1 day of left sided chest pain radiating to the left arm, accompanied by decreased exercise tolerance. Physical examination was unremarkable, with normal blood pressure and heart rate, and no cardiac murmurs reported. Myocardial infarction was excluded by cardiac biomarkers and the absence of ST-segment elevations on the electrocardiogram (ECG). However, the ECG showed left ventricular hypertrophy (LVH) by voltage criteria, with asymmetric T-wave inversions in the lateral leads (Figure 1).

Given the ongoing chest pain and the concern for ischemic heart disease, a stress (regadenoson) radionuclide myocardial perfusion imaging single photon emission computed tomography (SPECT) study with the dual isotope protocol (rest ^{201}Tl; stress ^{99m}Tc-Sestamibi) was performed. SPECT slices and polar displays, illustrated in Figure 2, showed an asymmetrically thickened septum compared with other areas, and a moderate sized, severe reversible defect of the apex and the mid-to-distal anterior wall, overlapping the distal lateral wall. The polar plot display of the thallium images showed a ''solar'' pattern. Gated SPECT imaging showed normal LV systolic function without apparent wall motion abnormalities on visual assessment. However, on quantitative analysis of the stress images, there was lower percentage wall thickening at the apex compared with other myocardial segments. Based on the SPECT results, the patient was referred for cardiac catheterization that revealed a mild (~50%) mid-left anterior descending stenosis (Figure 3), an unremarkable left circumflex artery, and a right coronary artery that originated from the left coronary cusp that was angiographically free of disease (not shown). The left ventriculogram showed hyperdynamic systolic function with an ejection fraction (EF) of 77%, and the characteristic spade-like configuration at the apex during diastole (Figure 3).

Apical hypertrophy was visualized on a non-contrast enhancing, echocardiogram (Figure 3); giving the patient a diagnosis of apical variant hypertrophic cardiomyopathy with non-obstructive coronary artery disease. Her symptoms resolved with institution of a beta-blocker.

Patient #2 An 83 year-old female with history of hypertension, deep vein thrombosis, and cerebrovascular disease, presented to the emergency room with a 4-day history of substernal chest pain radiating to the epigastrium, and shortness of breath. Physical examination was notable for a soft ejection systolic murmur auscultated at the apex. Laboratory testing showed negative cardiac biomarkers. The ECG showed LVH by voltage criteria, with diffuse T-wave inversions in the limb and precordial leads (Figure 4).

An echocardiogram was performed, and showed hypertrophy of the LV apex, without wall motion abnormalities appreciated (Figure 5). To further exclude myocardial ischemia, the patient underwent a regadenoson SPECT dual isotope radionuclide imaging study that showed persistent prominent tracer uptake in the apex on both the stress and rest images (solar pattern), and a partially reversible defect of the inferior wall consistent with ischemia (Figure 6). The LV systolic function was normal and there were no apparent wall motion abnormalities seen on the gated stress images. The quantitative wall thickening analysis, however, showed a significantly decreased percentage wall thickening at the apex compared with the rest of the myocardium. A cardiac catheterization revealed 70% disease at the origin of the right posterior atrioventricular segment, with minor changes in the other coronary arteries (Figure 5). The LVEF was 65%, with the characteristic spade-like configuration at the apex during diastole (Figure 5). As the area of ischemia was small, the patient was treated with optimal medical therapy, with particular attention to maximizing beta-blocker therapy.

Discussion. Apical hypertrophic cardiomyopathy (apical HCM) is an uncommon phenotypic variant of hypertrophic cardiomyopathy, reported to be more

From the Department of Nuclear Medicine, Division of Cardiology, Department of Medicine, Montefiore Medical Center, Albert Einstein College of Medicine, Bronx, NY.

Reprint requests: Mark I. Travin, MD, Department of Nuclear Medicine, Division of Cardiology, Department of Medicine, Montefiore Medical Center, Albert Einstein College of Medicine, 111 East-210th Street, Bronx, NY 10467-2490; *mtravin@montefiore.org*.

J Nucl Cardiol 2012;19:172–6.
1071-3581/$34.00

doi:10.1007/s12350-011-9452-2

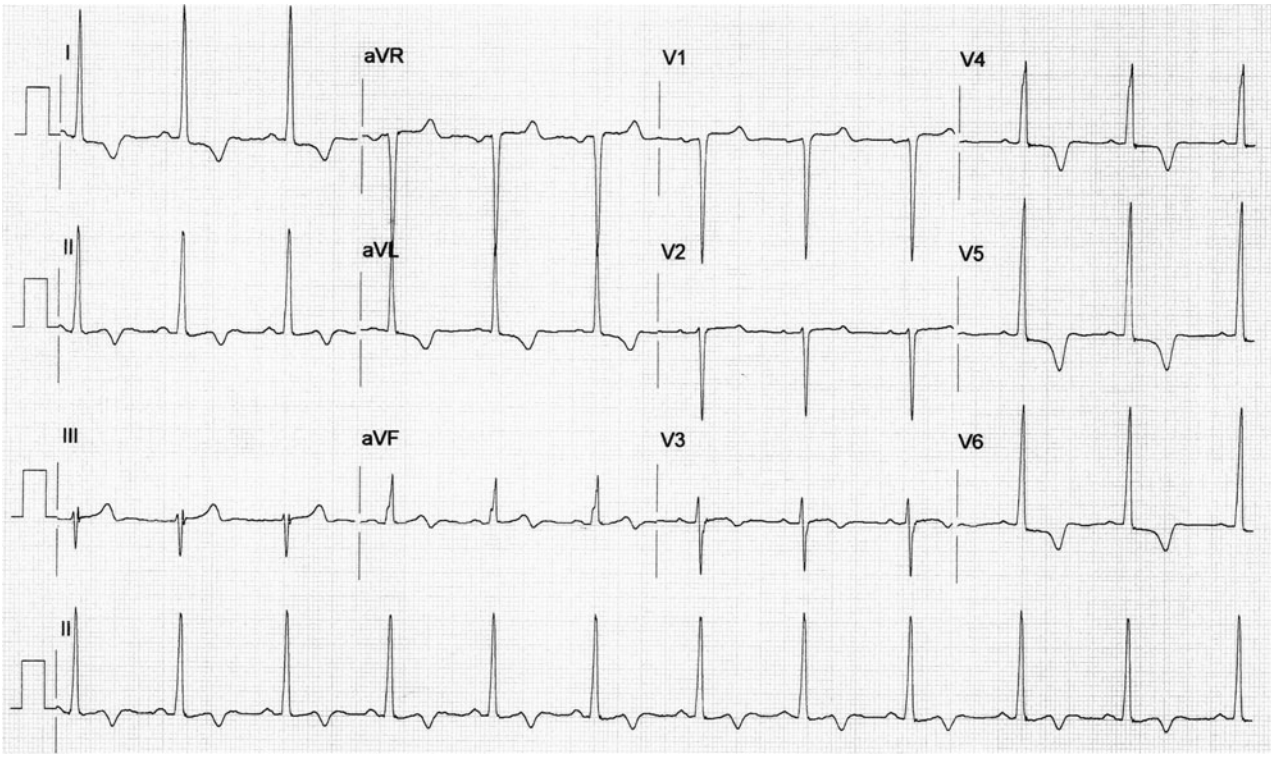

Figure 1. Electrocardiogram for case #1, showing left ventricular hypertrophy by voltage criteria with asymmetric lateral T-wave inversions.

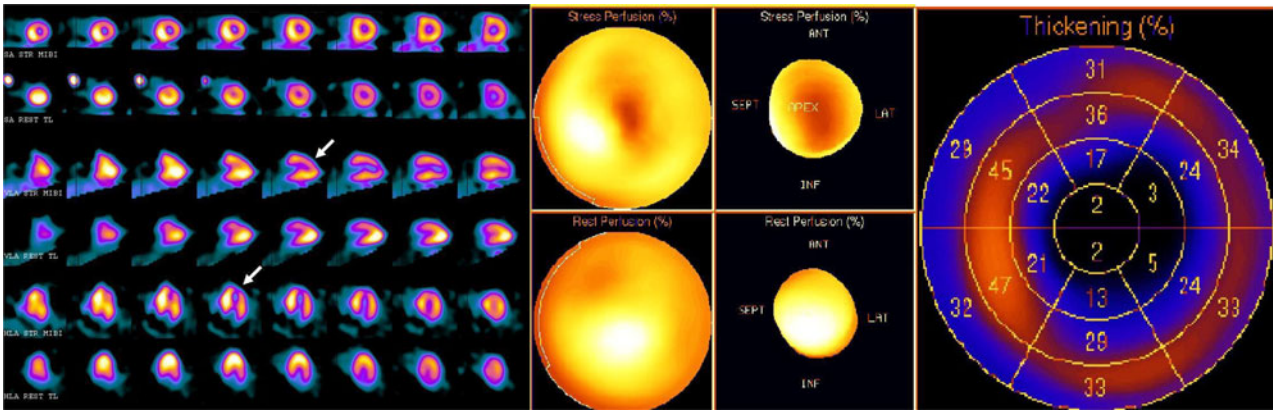

Figure 2. From *left to right*: regadenoson stress dual isotope images. The SPECT slices show an asymmetrically thickened septum, and reversible perfusion defect of the apex and the mid-distal anterior, wall overlapping the distal lateral wall (*arrows*). The stress polar plot display shows an apical perfusion defect, while the rest display shows a ''solar'' pattern. Quantitative wall motion analysis shows a lower percentage of apical wall thickening compared with the rest of the myocardial segments.

prevalent in Japan (18%) compared with western countries (3%-10%).[1] As the name implies, this disease entity is characterized by disproportionally prominent hypertrophy of the LV apex relative to the posterior or septal walls. The mechanism for formation of apical hypertrophy remains elusive, and no consistent sarcomere protein mutations have been identified.[2] However, it has been speculated that the sarcomere mutations that reproducibly produce apical HCM affect stretch activation within apical myocytes.

Being a relatively benign form of HCM, patients with apical HCM are often diagnosed serendipitously during investigation for HCM related or unrelated cardiac symptoms. As demonstrated in our cases, the first

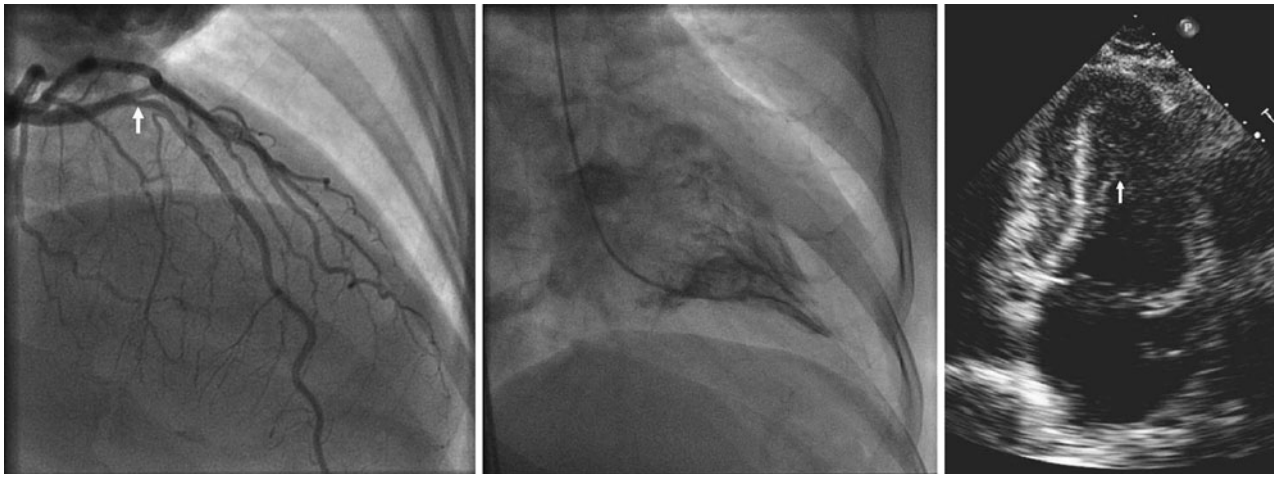

Figure 3. From *left to right*: coronary angiogram shows an approximately 50% stenosis of the mid-left anterior descending artery (*arrow*). The left ventriculogram shows the spade-shaped configuration at the apex during diastole. Echocardiography (apical two chamber view) shows localized apical hypertrophy (*arrow*).

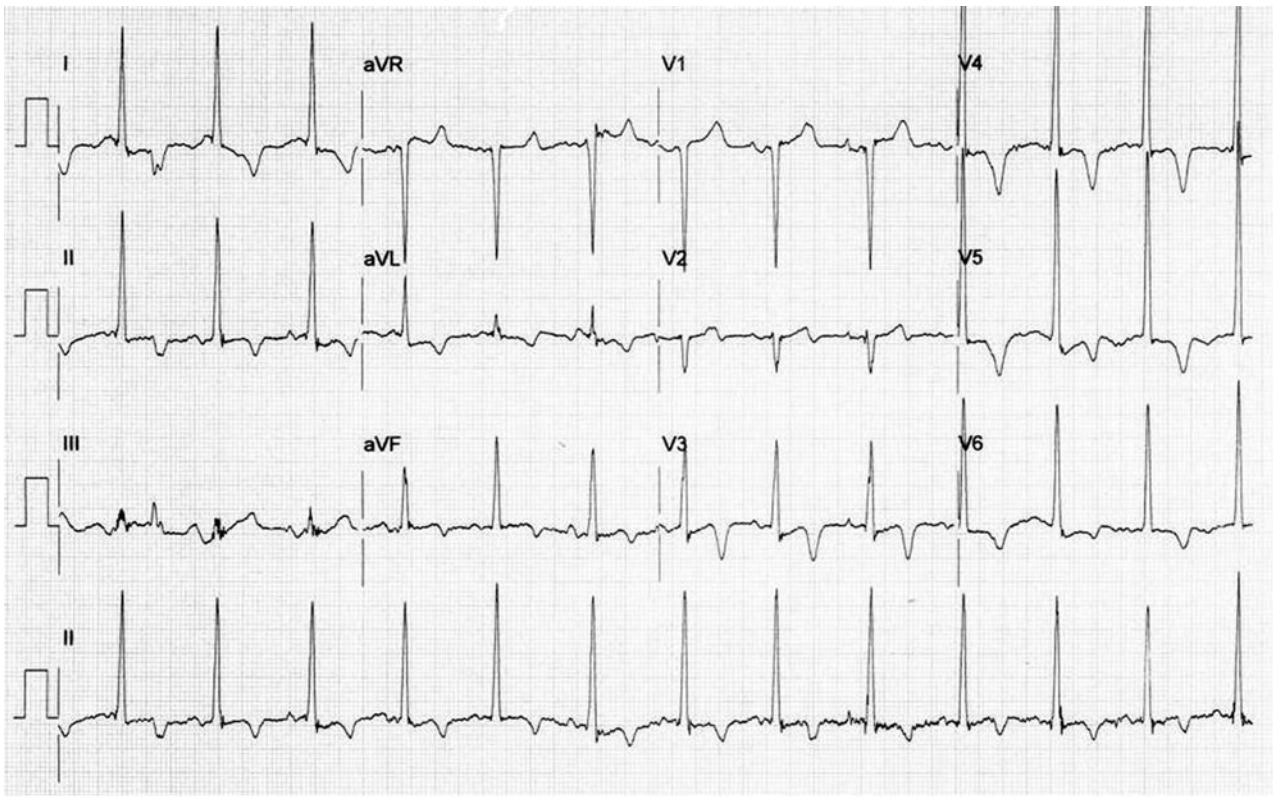

Figure 4. Electrocardiogram for case #2, showing left ventricular hypertrophy by voltage criteria with diffuse T-wave inversions.

diagnostic clue often rests in the ECG, where there is LVH by voltage criteria and giant deep T-wave inversions in the lateral precordial leads, but these are non-specific. Image findings are more reliable, and characteristically include focal apical hypertrophy with a thickness 1.5 times that of the posterior wall on

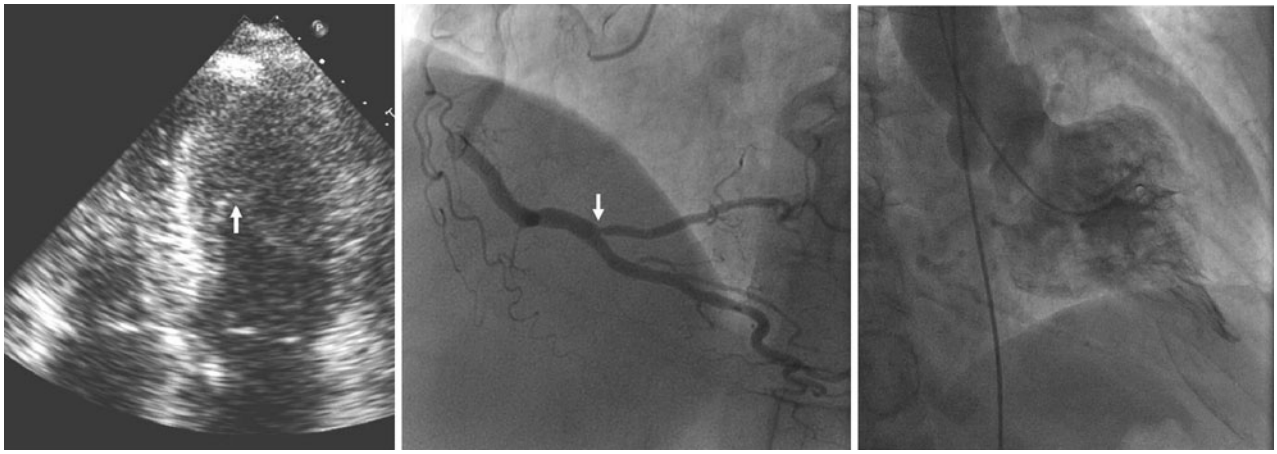

Figure 5. From *left to right*: the echocardiogram (apical four chamber view) shows localized apical hypertrophy (*arrow*). The coronary angiogram shows an approximately 70% stenosis at the origin of the right posterior atrioventricular segment. The left ventriculogram shows a spade-shaped configuration at the apex during diastole.

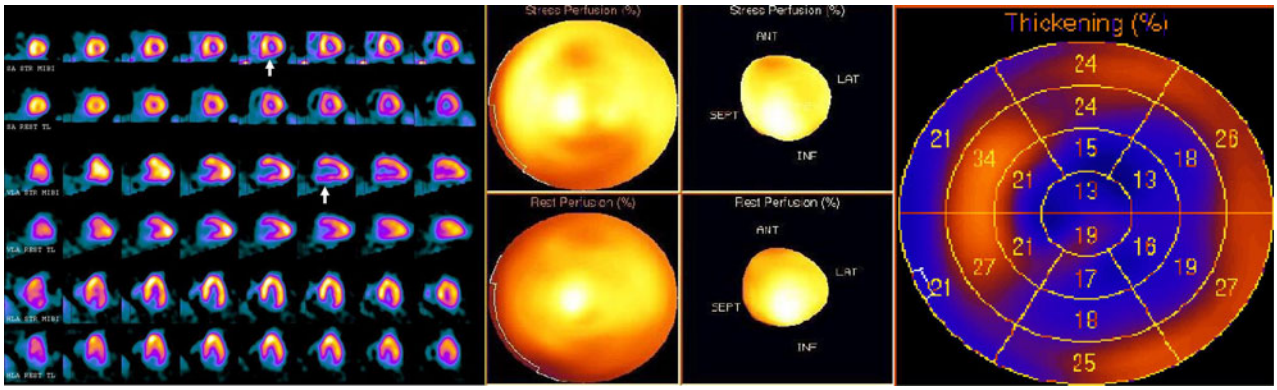

Figure 6. From *left to right*: regadenoson stress dual isotope images. The SPECT slices show a partially reversible perfusion defect of the inferior wall, and prominent apical tracer uptake manifest as a ''solar'' pattern on the polar plot displays (*arrows*). The wall motion map showed a lower percentage of apical wall thickening.

echocardiography; a spade-like configuration of the apex on invasive left ventriculogram during end-diastole; and prominent radiotracer uptake at the apex on radionuclide imaging giving rise to a solar pattern on a polar map display.[3] Cardiac magnetic resonance (CMR) imaging allows optimal definition of the hypertrophic segment and identifies various geometric subtypes of apical HCM.[4] Among the different imaging modalities, CMR is the most sensitive and specific, while radionuclide imaging yields variable perfusion patterns, and therefore should be interpreted with caution in the setting of apical HCM.

A ''solar'' polar pattern is often seen in apical HCM, and occurs because of the partial volume effect on SPECT reconstruction and limited spatial resolution.[5] On the other hand, conditions such as ischemia, infarction or increased collagen matrix inherent in the progression of HCM, known to decrease apical blood flow and relative myocyte to scar tissue content, can result in normal or decreased apical uptake.[3,5] The resting ^{201}Tl imaging study for patient 1 showed the ''solar'' pattern due to prominent apical tracer uptake, but the regadenoson stress ^{99m}Tc-Sestamibi images showed an apical perfusion defect that extended to the mid-distal anterior wall, possibly from myocardial ischemia (there was a 50% mid-LAD stenosis, and possibly microvascular dysfunction as well). It is of interest to note that there was increased radiotracer uptake in the septum on the ^{99m}Tc-Sestamibi stress imaging compared with the resting Thallium study.

Because concomitant asymmetric septal hypertrophy was excluded by echocardiography, we speculate that decreased apical and anterior wall tracer uptake during stress could account for exaggerated enhancement of the septum.

In contrast to patient 1, the myocardial perfusion pattern in patient 2 showed persistent prominent apical uptake during stress and rest. However, there was a reversible defect of the inferior wall. In the setting of angina, the myocardial perfusion pattern identified an area of ischemia, subsequently demonstrated by coronary angiogram to possibly be from a moderate stenosis of the right coronary artery at the origin of the right posterior atrioventricular branch.

Thus, the two cases of apical HCM presented here show a typical prominent apical tracer uptake pattern. While this finding alone is neither sensitive nor definitely diagnostic of apical HCM, it is a highly specific sign and should therefore raise suspicion for the condition. Stress radionuclide imaging also accurately detects myocardial ischemia that is common in HCM, more often secondary to perfusion/demand mismatch at the microvascular level than an epicardial coronary stenosis that is demonstrated in one of the cases here.[6] The detection of abnormal LV function and wall motion, particularly in the setting of HCM, however, is not as reliable because of the partial volume effect. This is demonstrated in the lower increase in radioisotope counts at the apex during systole, interpreted as lower percentage increase in wall thickening on computer quantitation. This is in contrast to the disproportionally increase in percentage wall thickening at the apex (compared to other myocardial segments) that is expected in a normal contractile pattern.[7] While partial volume effect may explain the abnormal radioisotope count change at the apex, other possible mechanisms such as abnormal apical myocardial contractile function may also be present.[8]

Although we do not have a definitive proof of ischemia as the cause of perfusion defect on the nuclear SPECT in the patients presented above, the improvement of symptoms with anginal medications and prior report of decreased coronary flow reserve in apical HCM support ischemia as a possible explanation for our patients' symptoms.[9] Despite the argument one can make about radionuclide imaging misleading the provider for patient 1 into performing an unnecessary invasive coronary angiogram, a demonstration of myocardial ischemia as a possible cause of the patient's presenting symptoms, and the exclusion of intervenable epicardial disease, supports the value of the radionuclide myocardial perfusion imaging study.

Conflict of interest

None.

Funding source

None.

References

1. Kitaoka H, Doi Y, Casey SA, Hitomi N, Furuno T, Maron BJ. Comparison of prevalence of apical hypertrophic cardiomyopathy in Japan and the United States. Am J Cardiol 2003;92:1183-6.
2. Arad M, Penas-Lado M, Monserrat L, Maron BJ, Sherrid M, Ho CY, et al. Gene mutations in apical hypertrophic cardiomyopathy. Circulation 2005;112:2805-11.
3. Cianciulli TF, Saccheri MC, Masoli OH, Redruello MF, Lax JA, Morita LA, et al. Myocardial perfusion SPECT in the diagnosis of apical hypertrophic cardiomyopathy. J Nucl Cardiol 2009;16:391-5.
4. Suzuki J, Watanabe F, Takenaka K, Amano K, Amano W, Igarashi T, et al. New subtype of apical hypertrophic cardiomyopathy identified with nuclear magnetic resonance imaging as an underlying cause of markedly inverted T waves. J Am Coll Cardiol 1993;22:1175-81.
5. Ward RP, Pokharna HK, Lang RM, Williams KA. Resting ''Solar Polar'' map pattern and reduced apical flow reserve: Characteristics of apical hypertrophic cardiomyopathy on SPECT myocardial perfusion imaging. J Nucl Cardiol 2003;10:506-12.
6. Eriksson MJ, Sonnenberg B, Woo A, Rakowski P, Parker TG, Wigle ED, et al. Long-term outcome in patients with apical hypertrophic cardiomyopathy. J Am Coll Cardiol 2002;39:638-45.
7. Sharir T, Berman DS, Waechter PB, Areeda J, Kavanagh PB, Gerlach J, et al. Quantitative analysis of regional motion and thickening by gated myocardial perfusion SPECT: Normal heterogeneity and criteria for abnormality. J Nucl Med 2001;42:1630-8.
8. Reddy M, Thatai D, Bernal J, Pradhan J, Afonso L. Apical hypertrophic cardiomyopathy: Potential utility of strain imaging. Eur J Echocardiogr 2008;9:560-2.
9. Bertrand ME, Tilmant PY, Lablanche JM, Thieuleux FA. Apical hypertrophic cardiomyopathy: Clinical and metabolic studies. Eur Heart J 1983;4:127-33.