Technetium-99m Gated SPECT Imaging for Evaluation of Global and Regional Left Ventricular Function: Comparison to Quantitative Echocardiography

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GLOBAL VE BÖLGESEL SOL VENTRİKÜL FONKSİYONUNUN DEĞERLENDİRİLMESİNDE GATED TEKNESYUM-99m SPECT GÖRÜNTÜLEME: KANTİTATİF EKOKARDİYOGRAFİ İLE KARŞILAŞTIRILMASI

ÖZET

Gated SPECT görüntülemeyle, sol ventrikül global ve bölgesel fonksiyonlarının değerlendirilmesindeki güvenilirliğini ekokardiyografi ile karşılaştırmak amacıyla, 35 hasta çalışmaya alındı. Hastalara aynı günde olacak şekilde gated Tc-99m sestamibi SPECT görüntüleme ve ekokardiyografi uygulandı. 14 hasta daha önce miyokard infarktüsü (MI) geçirmişti. Ekokardiyografik duvar hareketi değerlendirmesi 16 segmentli modelde 4 puanlı sisteme göre yapıldı. Bu 16 segmente uyan gated SPECT görüntülerde, duvar hareketi ve sistolik kalın-laşma da 4 puanlı sistemlere göre (sırasıyla 3=normal, 0=akinezi/diskinezi; ve 3=normal, 0=kalınlaşma yok) değerlendirilerek ekokardiyografi ile karşılaştırıldı. Gated SPECT horizontal uzun eksen görüntüler video kamera ile görüntülenerek kayıt aynı ekokardiyografi cihazında izlendi. Tüm hastalarda planimetrik olarak Simpson metodu ile EF ölçüldü. Gated SPECT ve ekokardiyografi arasında duvar hareketi (%74, kappa=0.43, p<0.001) ve sistolik kalınlaşma (%73, kappa=0.43, p<0.001) açısından oldukça iyi bir segmenter skor uyumluluğu saptandı. Yine, duvar hareketi ve sistolik kalınlaşma yönünden iki yöntem arasında belirlenen korelasyon oldukça iyi idi (r=0.93 ve r=0.97). Gated SPECT görüntülerde EF ölçümünün tekrarlanılabilirliği oldukça yüksekti (aynı gözlemcide r=0.97, farklı gözlemciler arasında r=0.93). Sonuçta; Gated SPECT görüntülemeyle kullandığımız teknik, bölgesel sol ventrikül fonksiyonunun değerlendirilmesi ve EF ölçümünde ekokardiyografi ile iyi bir uyum göstermektedir.

Anahtar kelimeler: *Gated SPECT, sol ventrikül fonksiyonu, ekokardiyografi*

Received: 6 November 2001, accepted 13 March 2001
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This study has been presented as a poster presentation in XXth European Congress of Cardiology (Vienna, August 22-26, 1998).

Technetium-99m sestamibi has recently been introduced for use with SPECT imaging for evaluation of coronary artery disease [1-4]. Tc-99m sestamibi may be given in high doses due to its short half-life compared to thallium-201 and together with its higher energy result in improved image quality [5,6]. The high count density in each image and the stable myocardial distribution allow acquisition of gated tomograms sychronized to the electrocardiogram for assessment of global and segmental myocardial contraction. The accuracy of gated SPECT imaging for evaluation of regional and global left ventricular function has been investigated in the last decade [7,8]. Regional wall motion and systolic thickening data from gated myocardial perfusion SPECT has shown good correlation with two-dimensional echocardiography [7,8]. Several studies have shown that left ventricular ejection fraction can be measured from gated Tc-99m sestamibi SPECT imaging using either automatic quantitation or manual tracing of endocardial borders [9-11]. In the present study, segmental and global left ventricular functional data from gated SPECT imaging was compared to quantitative echocardiographic data and a new technique was developed for calculation of left ventricular ejection fraction.

METHODS

Study patients: The study group consisted of 35 patients (24 men, 11 women, mean age 57±14 years) referred to our nuclear cardiology laboratory. Fourteen patients had previous myocardial infarction and five patients had prior coronary artery bypass surgery.

SPECT acquisition protocol: All patients were investigated according to a one-day rest/stress protocol. For the rest studies, tomographic images were obtained 60 minutes after the intravenous injection of 8mCi of Tc-99m

sestamibi. An Elscint APEX SPX gamma camera equipped with a low energy, all purpose collimator with a 20% window centered at the 140 keV photopeak of tc-99m was used. Sixty projections of 20 sec each were acquired in step and shoot mode over a 180-degree arc on 64x64 matrixes with a zooming factor of 1.4. Patients underwent stress testing with a standard Bruce treadmill and at peak stress, 22 mCi of Tc-99m sestamibi was injected. After 60 minutes, gated SPECT imaging was performed. The same imaging variables as for the rest study were used with the addition of ECG-gated projection for tomoraphic reconstruction. At each projection, eight ECG-gated frames per cardiac cycle were acquired. The image reconstruction was performed using a Butterworth filter with a cut-off frequency of 0.35 Nyquist and an order of 5 for Tc-99m sestamibi perfusion imaging and a Metz filter for ECG-gated SPECT imaging. Horizontal long axis images were taken on a video camera to be displayed subsequently on echocardiography.

Image analysis: Left ventricular images were scored using a four-point scale on the 20-segment model (0=normal, 1=equivocal, 2=moderate, 3=severe reduction in radioisotope uptake; 4=absent uptake) [12]. The gated end-systolic and end-diastolic images were interpreted and segmental wall motion was scored on a four-point scale (0=akinesia/dykinesia, 1=severe hypokinesia, 2=moderate hypokinesia, 3=normal) in the same 20 segments [12]. When functional assessment could not be performed because of severe reduction or absence of radioisotope uptake, these segments were assigned scores of zero for wall motion [8].

Echocardiographic study: Two-dimensional echocardiograms were performed after the stress Tc-99m sestamibi acquisition using a Vingmed with 2.5 HHz transducer. Echocardiograms were examined by two cardiologists unaware of Tc-99m sestamibi findings. Ejection fraction was calculated by planimetric tracing in the four-chamber view. Wall motion and systolic thickening were graded on a four-point scoring system similar to Tc-99m sestamibi images on the 16-segment model. The basal and midventricular short axis views on gated SPECT were compared with the corresponding basal and midventricular short axis views on echocardiography, the apical short axis inferoseptal and high lateral segments on SPECT with apical septal and lateral segments on echocardiography and vertical long-axis inferoapical and anteroapical segments on SPECT with apical inferior and anterior segments on echocardiography. Global wall motion and systolic thickening scores were calculated from the sum of scores of all 16 segments.

Statistical analysis: Agreement for global and regional wall motion scores were assessed by kappa analysis. The correlation between gated SPECT and echocardiographic values for global wall motion and systolic thickening were analyzed by Pearson correlation analysis. SPSS 7.5 version was used for statistical analyis.

RESULTS

The agreement between Tc-99m sestamibi myocardial imaging and echocardiography for segmental wall motion and systolic thickening were displayed in Tables 1-2. There was a high segmental score agreement between gated SPECT and echocardiography for wall motion (74%, k=0.43, p<0.001) and systolic thickening (73%, k=0.43, p<0.001). Pearson correlation analysis also revealed excellent correlation between the two methods for wall motion (r=0.93) and systolic thickening (r=0.97). Repeated measures of ejection fraction on gated SPECT showed high degree of reproducibility for the same and different observers (intraobserver r=0.97; interobserver r=0.93). There was a strong correlation for ejection fraction between gated SPECT and echocardiography in patients with and without myocardial infarction (r=0.72, r=0.96, respectively). In a subgroup analysis, segmental score agreement between gated SPECT imaging and echocardiography was 0.64 for patients with and 0.87 for patients without previous myocardial infarction.

Table 1. Comparison of segmental score agreement between gated SPECT imaging and echocardiography for wall motion

Gated SPECT	Echocardiography			
Wall Motion Score	3	2	1	0
3	345	36	5	0
2	56	41	6	0
1	4	28	8	0
0	1	4	8	18

Table 2. Comparison of segmental score agreement between gated SPECT imaging and echocardiography for systolic wall thickening

Gated SPECT	Echocardiography			
Wall Motion Score Thickening	3	2	1	0
3	342	44	2	0
2	48	34	6	1
1	2	31	16	2
0	1	4	6	21

DISCUSSION

An important advantage of technetium-99m sestamibi over standard thallium-201 imaging is the high count density which permits gated acquisition for evaluation of global and segmental left ventricular

function [5,6]. Recent studies have investigated the reproducibility and accuracy of technetium-99m sestamibi imaging for assessment of left ventricular function. Najin et al [13] showed that the measurement of fractional shortening from the diastolic and systolic anterior technetium-99m sestamibi images correlated well with echocardiographic fractional shortening. Tischler et al [7] reported that segmental wall motion analysis determined from gated planar technetium-99m sestamibi myocardial imaging was highly reproducible and agreed well with echocardiographic data. Intra- and interobserver agreement was extremely high for global and segmental technetium-99m sestamibi wall motion analysis in their study. They have suggested that the differences in planar versus tomographic technique might be responsible for some of the disagreements between sestamibi imaging and echocardiography and SPECT imaging would be a better approach to compare the two techniques. Chua et al [8] also found that gated SPECT imaging showed good correlation with echocardiographic assessment of regional function (r=0.96).

Our results agree with these findings. We found that global and segmental left ventricular function determined from gated technetium-99m sestamibi gated SPECT imaging agreed extremely well with echocardiography. There was high segmental score agreement between gated SPECT and echocardiography for wall motion and systolic thickening in our study ($p<0.001$, $p<0.001$). Moreover, we also found a high degree of intra- and interobserver agreement for global and segmental left ventricular function. Recently, several studies have shown that left ventricular ejection fraction can be measured from gated technetium-99m sestamibi SPECT imaging by either automatic ejection fraction quantitation or by manually tracing the endocardial borders [9-11]. In these studies, ejection fraction calculated from gated images showed good correlation with standard techniques such as radionuclide angiography and contrast ventriculography [14]. In the present study, repeated measures of ejection fraction on gated SPECT showed a high degree of reproducibility for the same and different observers. Moreover, the correlation for ejection fraction of patients with and without myocardial infarction was also good (r=0.72, r=0.96) (Figure 1).

Our method provides a new technique comparable to for echocardiography determining ejection fraction in patients undergoing Gated SPECT.

Study limitations

Assessment of segmental wall motion and systolic wall thickening on gated images might be difficult

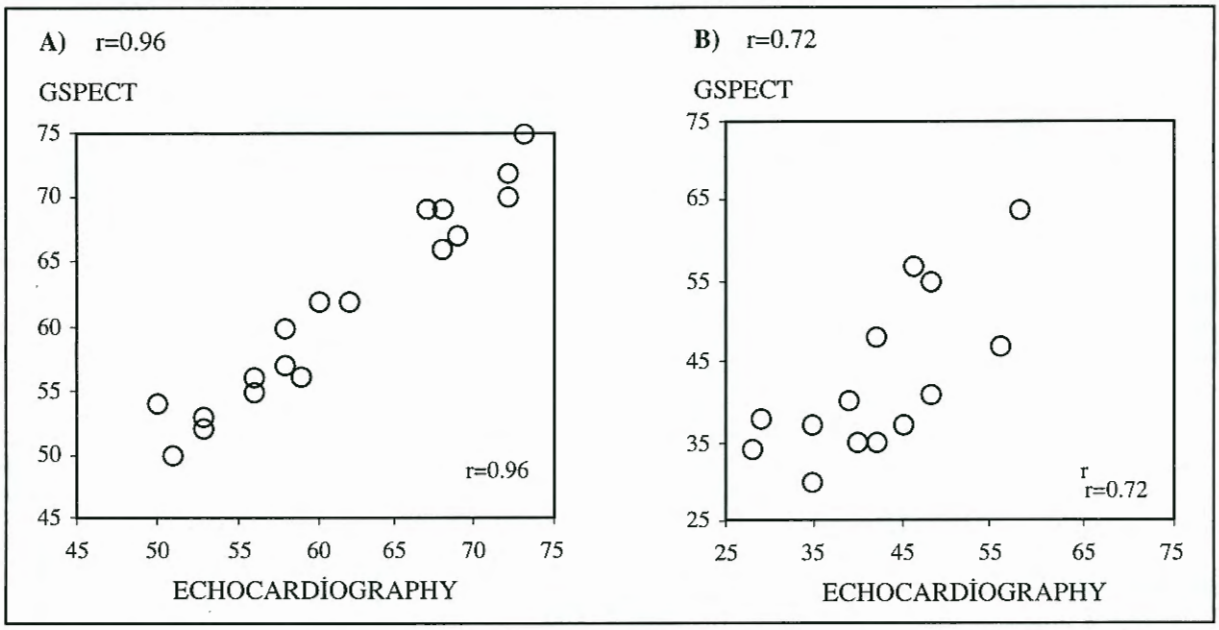

Figure 1. Correlation for ejection fraction between gated SPECT and echocardiography in patients without (A) and with myocardial infarction (B).

when tracer uptake is severely reduced or absent and this might be responsible for some of the disagreement for wall motion abnormalities between the two methods. An important limitation of post-stress gated myocardial perfusion SPECT for measuring left ventricular ejection fraction is that although these post-stress images accurately define rest left ventricular function in patients with normal myocardial perfusion or only fixed perfusion defects, these data must be evaluated cautiously in the setting of reversible myocardial ischemia [15]. Future studies including a greater population may be planned for comparison of wall motion of ischemic segments with the two techniques.

In conclusion, our data suggest that gated SPECT imaging shows good correlation with echocardiography for both regional and global left ventricular function and calculation of ejection fraction by this technique shows high degree of reproducibility.

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