Original Article

Assessment of Diastolic Function Parameters with ECG Gated Myocardial Perfusion Spect: Comparison of Two Algorithms

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Background: To compare Cedars-Sinai QGS and Michigan University Corridor4DM algorithms for determination peak filling rate (PFR), time to peak filling rate (TPFR) and mean filling rate in first third of diastole (MFR3) using 16 frames gated myocardial perfusion single photon emission computed tomography (SPECT). To determine inter-observer reproducibility of Cedars QGS and Michigan University Corridor4DM for determination PFR, TPFR and MFR3 using 16 frames gated myocardial perfusion SPECT.

Methods: Forty patients (28 males and 12 females) with age range 35-70 years (mean 58.85±8.82) referred for assessment of left ventricular perfusion and function were included in the study. All patients were injected 1100 Mega Becquerel (MBq) of freshly prepared ^{99m}Tc Sestamibi. One hour later, patients underwent gated myocardial perfusion SPECT on Siemens ecam® dual head variable angle gamma camera using 16 frames per cardiac cycle. Data were reconstructed using filter back projection and re-orientated to generate short axis slices. Short axis slices were processed with QGS and Corridor 4DM for assessment of PFR, TPFR and MFR3 by two observers. Data from both observers were compared to determine inter-observer reproducibility of both methods. Observer1 PFR, TPFR and MFR3 values derived from QGS and Corridor4DM were compared and correlated.

Results: Peak filling rate values determined with Cedars QGS program were not significantly different from those determined with Corridor4DM (p= 0.564). Good correlation was found between QGS and 4DM measured PFR values (R^2=0.6698). TPFR values determined with QGS program were not significantly different from those determined with Corridor 4DM program (p= 0.615). However, there was poor correlation between these two methods with R^2 value =0.0382. MFR3 values determined with QGS were not statistically different from those derived from 4DM (p=0.587). However, there was poor correlation between these values R^2= 0.0174. Cedars QGS algorithm was highly reproducible for determination of PFR, TPFR and MFR/3 with R^2 values of 0.9922, 0.9874 and 0.9932 respectively. PFR, TPFR and MFR3 derived from Corridor4DM were also highly reproducible with R^2 values of 0.7775, 0.8381 and 0.456 respectively.

Conclusions: Both Cedars QGS and Michigan University Corridor 4DM programs are robust for determination of PFR, TPFR and MFR3 diastolic function parameters. There is good correlation between QGS and 4DM derived PFR measurements. However, there is poor correlation between QGS and 4DM derived TPFR and MFR3 values.

Key words: PFR, TPFR, MFR3, QGS, Corridor4DM and Gated SPECT

Introduction

ECG gated myocardial perfusion SPECT allows the simultaneous assessment of myocardial perfusion and function, particularly for left ventricular myocardium.[1-3] Gated SPECT has been extensively used to calculate left ventricular ejection fraction along with volumes and also been clinically validated with echocardiography, first pass study and magnetic resonance imaging.[4-7] Moreover, it is possible to assess global as well as regional left ventricular function.[8]

The concept of assessing left ventricular diastolic function parameters with gated myocardial perfusion SPECT is relatively new. Higuchi T et al determined the feasibility of evaluating left ventricular filling rates with gated SPECT and showed a good correlation with radionuclide angiography.[9] The diastolic parameters calculated from Gated myocardial perfusion SPECT are peak filling rate (PFR), time to peak filling rate (TPFR) and mean filling rate (MFR).

Gated myocardial perfusion SPECT can provide accurate information about left ventricular systolic as well as diastolic function.[10,11] In order to accurately measure the diastolic events, a large number of acquisition frames must be used.[12,13] Although 8 or 16 R-R interval gated SPECT is widely used, it is not adequate for evaluation of diastolic function. Gated Myocardial Perfusion SPECT with 32 R-R intervals acquisition has proven appropriate for assessment of diastolic function.[14] PFR, TPFR measurements with gated myocardial perfusion SPECT have been validated against those of radionuclide angiography.[15] It is also important to use narrow gating tolerance i.e. all beat lengths should be within about 5% of one another. Variability in the R-R interval will greatly affect the resulting volume curve and consequently the accuracy of all diastolic function parameters. The acceptance window of ±10-20% has been used in different studies.[16]

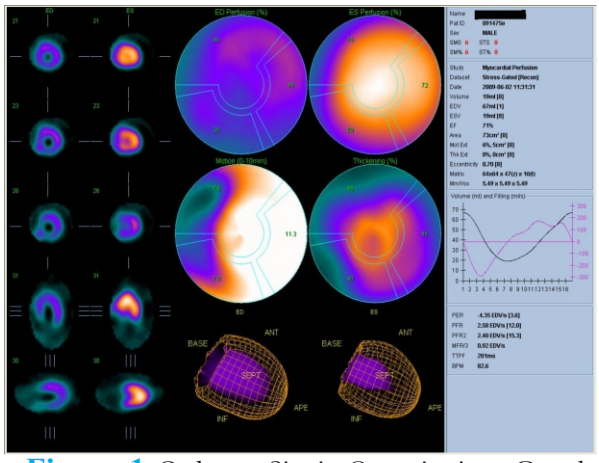

Figure-1: Cedars- Sinai Quantitative Gated SPECT (QGS) program for assessment of LV systolic and diastolic function parameters. QGS uses 16 or 32 frames per cardiac cycle gated SPECT data for assessment of diastolic function variables. Peak ejection rate (PER), peak filling rate (PFR), secondary peak filling rate (PFR2), Mean filling rate over first one third diastole (MFR3) and time to peak filling (TTPF).[19]

Several kinds of automated software are available for the quantitative assessment of the left ventricular function by gated SPECT, and they are well validated and utilized. Some of commercially available algorithms for quantitative gated SPECT are Cedars Sinai QGS (figure 1), Michigan University Corridor 4DM (figure 2) and Emory Toolkit. All of these quantitative gated SPECT programs have been validated against other techniques for assessment of systolic function. Cedars QGS and Michigan University Corridor4DM are also capable of automatically determining diastolic function parameters. These programs have been shown to have good reproducibility. However, QGS have a more stable contour finding and is less susceptible to variation.[17] QGS derived normal values of PFR and TPFR with 16 frame gated myocardial perfusion SPECT are 2.70±0.50 EDV/Sec and 162.3+16.2 msecs respectively.

Threshold values for abnormal PFR and TPFR by gated SPECT are 1.72 EDV/Sec and 216.7 msec respectively.[18]

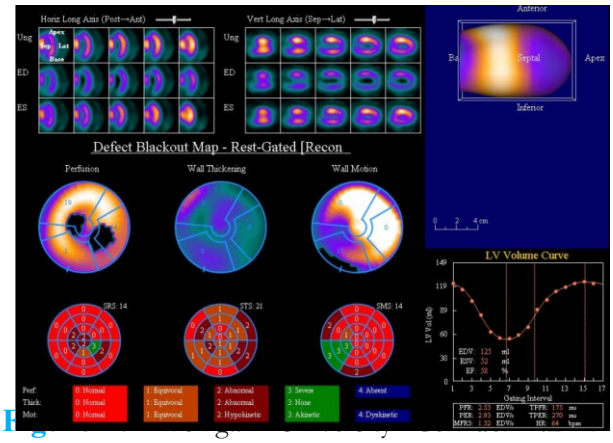

Figure-2: Corridor 4DM algorithm for assessment of LV systolic and diastolic function parameters: Peak filling rate (PFR), Peak ejection rate (PER), First one third mean filling rate (MFR3), Time to peak filling rate (TPFR) and Time to peak ejection rate TPER). Corridor 4DM algorithm requires 16 frames per cardiac cycle gated SPECT data for assessment of diastolic function parameters.[20]

Aims and Objectives

To compare Cedars-Sinai QGS and Michigan University Corridor4DM algorithms for determination PFR, TPFR and MFR3 using 16 frames gated myocardial perfusion SPECT.

To determine inter-observer reproducibility of Cedars QGS and Michigan University Corridor 4DM for determination PFR, TPFR and MFR3 using 16 frames gated myocardial perfusion SPECT.

Patients and Methods

Forty patients with intermediate probability for coronary artery disease referred for assessment of myocardial perfusion and function. Informed written consent was taken from all patients included in the study.

Exclusion Criteria

All patients with unstable angina.
All patients with advanced systemic diseases e.g. chronic renal failure.
All patients with associated advanced valvular lesions.
All patients with associated premature ventricular contractions 10.
All patients with AV and bundle branch blocks (BBB).

Gated Myocardial Perfusion SPECT

Patients were asked to come fasting for 4 to 5 hours before the study, to minimize the gall bladder activity. All medications were stopped 24 hours before the test. History and brief general physical examination done before study commenced. All study subjects were injected 1100 MBq of the ^{99m}Tc sestamibi through secured intravenous line, in accordance with the radiation protection practice. Patients were asked to have a light fatty meal 15 to 20 minutes after the injection. Resting gated myocardial perfusion SPECT was acquired 30-60 minutes after injection.
Tomographic imaging was done on Siemens ecam dual head variable angle gamma camera (90 degree configuration) over a 180 degrees arc starting from right anterior oblique (135°) to left posterior oblique (315°), using auto body contouring. A 20% symmetric energy window centered at 140 keV was used for acquisition. An acquisition zoom of 1.4 was used. Acquisition was done at 16 frames per cardiac cycle in step and shoot manner using 32 steps, each of 60 seconds. The R-R acceptance value set at 20% of the mean R-R interval. Total acquisition time was 20 minutes. Gated SPECT data were stored on magnetic disc by means of 64×64 word matrix
The raw data was checked to see for patient motion and any motion observed was corrected using proprietary motion correction algorithm. Image reconstruction was done with 180-degree filtered back projection using ramp filter. Butterworth filter with a 0.21 cut-off frequency and order 5.0 was used for 3-D post filtering. Short axis slices were processed with Cedars-Sinai QGS and Michigan University Corridor4DM algorithms on esoft® workstation. All data processing was carried out by two independent observers (observer 1, observer 2). Data from observer1 was used to compare and correlate QGS and Corridor4DM. Data from observer 1 and observe 2 were used to determine inter-observer reproducibility of both algorithms.

Statistical Analysis

T test was used to compare means of diastolic function variables PFR, TPFR and MFR3 determined with QGS and Corridor4DM algorithms. Correlation coefficient (R^2) was determined to find correlation between parameters determined with both algorithms.

Results

The study population comprised 40 patients (28 males and 12 females). The age range was 35- 70 years (mean 58.85±8.82 years). Heart rate during acquisition ranged between 57 and 123 (mean 79.85±15.7).
Peak filling rate determined with Cedars QGS program was not significantly different from that determined with Corridor 4DM (p= 0.564). Good c
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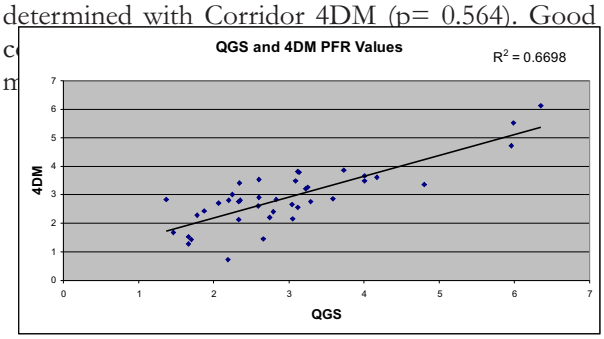

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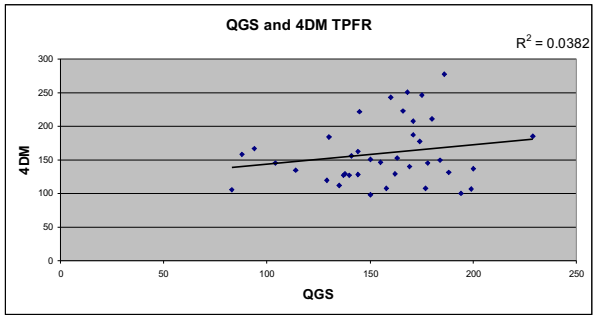

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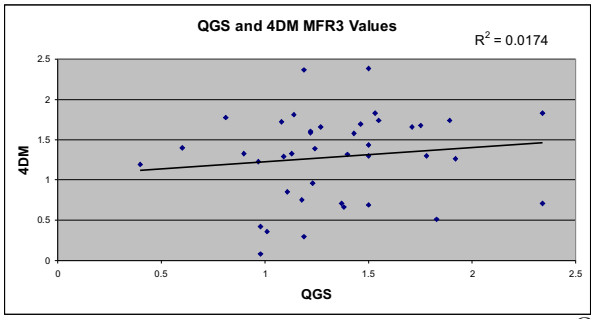

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TPFR values determined with QGS program were not significantly different from those determined with Corridor 4DM program (p= 0.615). However, there was poor correlation between these two methods with R^2 value =0.0382 (figure 3B). MFR3 values determined with QGS were not statistically different from those derived from 4DM (p=0.587). However, there was poor correlation between these values R^2= 0.0174 (figure 3C).

Reproducibility of QGS

Cedars QGS algorithm was highly reproducible for determination of PFR, TPFR and MFR3 with R^2 values of 0.9922, 0.9874 and 0.9932 respectively (Figure 4).

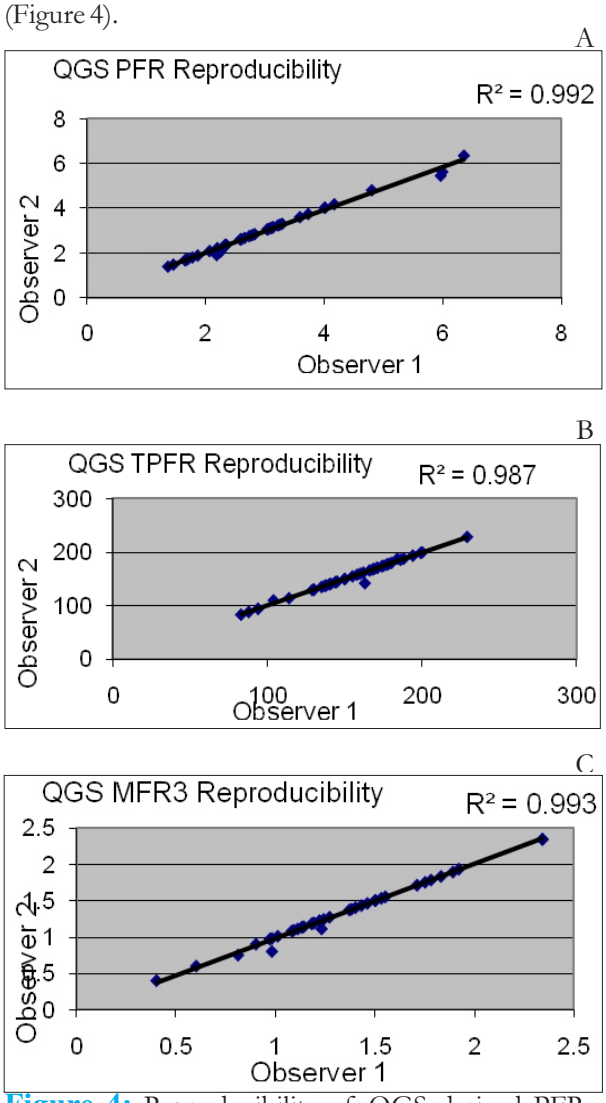

Figure 4: Reproducibility of QGS derived PFR (A), TPFR (B) and MFR3 ©.

Reproducibility of Corridor4DM

PFR, TPFR and MFR3 derived from Corridor 4DM were highly reproducible with R^2 values of 0.7775, 0.8381 and 0.456 respectively **(figure 5).**

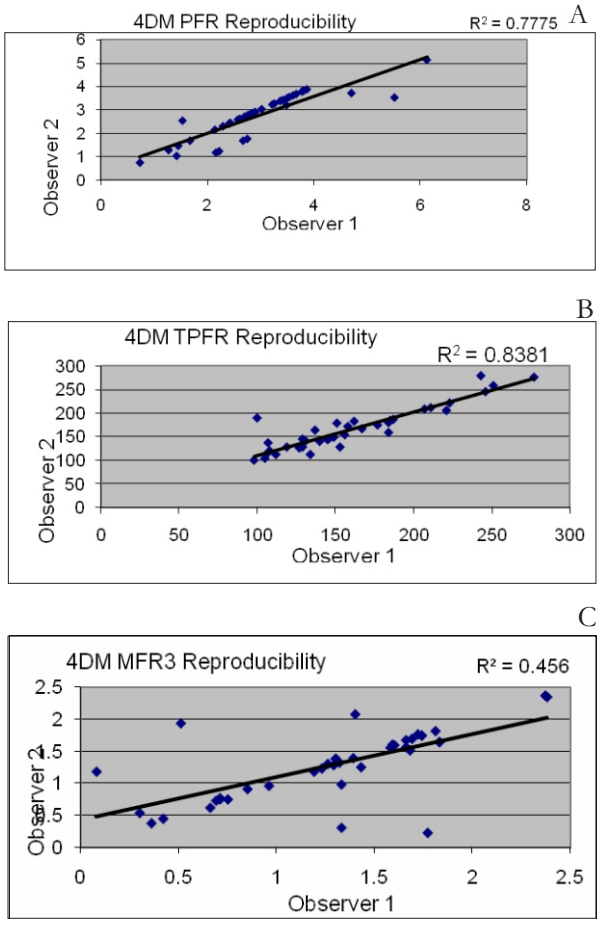

Figure 5: Reproducibility of Corridor4DM derived PFR (A), TPFR(B) and MFR3©.

Discussion

Assessment of cardiac function is complimentary to myocardial perfusion in patients undergoing myocardial perfusion SPECT. There are many commercially available programs for assessment of left ventricular function. These include Cedars Sinai QGS, Michigan University Corridor4DM, Emory toolkit and many others. These programs are extensively tested and validated against other techniques for assessment of left ventricular systolic function parameters[4,15,20]. Although assessment of left ventricular diastolic function is not new to nuclear techniques, yet use of myocardial perfusion SPECT for assessment of diastolic function parameters is relatively new. New features has been added for quantitative gated SPECT analysis programs to assess diastolic function parameters in addition to myocardial perfusion and systolic function

Parameters[21]. Now there are validation studies for quantification of diastolic function with quantitative gated SPECT[11,18]. Nagamachi et al[21] has compared and correlated Cedars QGS program and Sapporo University pFAST algorithm and have found good correlation between the two methods Yamamoto et al have also show good reproducibility of pFAST[11]. Akincioglu has validated QGS program and established normal values for peak filling rate and time to peak filling[18]. However, there have not been many head to head comparisons of different techniques. Our study has shown excellent reproducibility of Cedars QGS as well as Corridor 4DM. Our study has also shown good correlation between QGS and Corridor4DM derived peak filling rate. However, there has been poor correlation between times to peak filling rate and (TTFR) and first third mean filling rate (MFR3). Though both the techniques have shown robustness and good reproducibility, at present these techniques cannot be used interchangeably. Further work is required for refinement of software algorithms for their routine use for assessment of diastolic function parameters in clinical practice.

Conclusions:

Cedars QGS program and Michigan University Corridor 4DM are robust for determination of PFR, TPFR and MFR3 diastolic function parameters. There is good correlation between QGS and 4DM derived PFR measurements. However, there is poor correlation between QGS and 4DM derived TPFR and MFR3 values.

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