Original Article

EVALUATION OF pFAST FOR ASSESSMENT OF LEFT VENTRICULAR VOLUMES AND EJECTION FRACTION: COMPARISON WITH ERNA AND QGS

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ABSTRACT

Gated SPECT is widely used for assessment of myocardial perfusion and function. Various algorithms are available for quantification of gated SPECT for assessment of LV function parameters. QGS has been extensively tested and validated with ERNA and angiographic data. pFAST is a new PC based package for quantitative gated SPECT display, analysis and report generating but still requires validation.

Objective: *This study is designed to evaluate pFAST algorithm for determination of left ventricular ejection fraction (EF), end diastolic volume (EDV) and end systolic volume (ESV) and compare the results with those of equilibrium radionucleide angiography (ERNA) and quantitative gated SPECT (QGS).*

Methods: *Fifty known coronary artery disease patients (28M, 22F) were enrolled for the study. All patients underwent resting gated myocardial perfusion SPECT with Tc-99m sestamibi and ERNA on two separate days on Prism 2000XP gamma camera interfaced with Odyssey VP computer. Gated SPECT data were acquired in 64 x 64 matrix over 180 degrees in step and shoot manner at 8 frames per cycle. ERNA data were acquired in standard LAO projection at 24 frames per cycle. Gated myocardial perfusion data were reconstructed into trans axial slices using a ramp filter. A 3D low pass filter of order 5.0 and cutoff frequency 0.21 was applied and slices were reoriented into short axis slices. Short axis slices were processed and analyzed with QGS algorithm on Odyssey VP computer. Short axis slices were converted to DICOM format and transferred to PC over LAN for processing with pFAST software. The results of ERNA, QGS and pFAST were compared with respect to EF, EDV and ESV.*

Results: *Excellent correlation was found between EF measured with pFAST and ERNA ($y = 0.9351$, $r^2 = 0.8012$), pFAST and QGS ($y = 0.9594$, $r^2 = 0.8125$). ESV and EDV volumes measured with pFAST also correlated with those of ERNA and QGS. However, pFAST overestimated EDV by 23% compared with ERNA and by 38% compared with QGS. Similarly pFAST overestimated ESV by 35% compared with ERNA and by 41% compared with QGS.*

Conclusions: *pFAST is highly reliable for assessment of EF but it overestimates left ventricular volumes.*

Key words*: Gated SPECT, pFAST, QGS, ERNA, EF, ESV, and EDV*

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INTRODUCTION

Gated Myocardial perfusion SPECT is increasingly used in most nuclear cardiology laboratories as it provides assessment of left ventricular ejection fraction and left ventricular volumes in addition to providing more accurate information about myocardial perfusion[1,2]. Assessment of left ventricular volumes and ejection fraction has additional prognostic value. The patients with depressed ejection fraction and large left ventricular volumes have reduced life expectancy; patients with preserved ejection fraction and normal sized cardiac chambers have good long-term survival[3,4].

Equilibrium radionuclide angiography (ERNA) still stands as standard for assessment of left ventricular volumes and ejection fraction; the accuracy of other techniques is judged with reference to ERNA. Quantitative gated SPECT also provides these functional parameters

However, the numeric values of these parameters are dependent on the algorithm used for endocardial edge detection. Various software programs have been used in quantitative gated SPECT for assessment of left ventricular functional parameters. QGS from Cidars-Sinai Medical Center is a fully automated program and has been extensively used and validated with first pass studies, ERNA, echocardiography, contrast ventriculography, and magnetic resonance imaging[5-8]. It has shown good correlation with other techniques.

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pFAST is a new Windows based program developed by University of Sapparo, Japan. It runs on PC and is capable of processing multiple venders gated SPECT data. Moreover, it is capable of reading DICOM data. pFAST has a friendly interface and runs fast on a Pentium PC (fig.1). It requires validation of volumetric measurements against other techniques. This study is designed to judge the diagnostic accuracy of this program by comparing it with ERNA and QGS for assessment of ejection fraction and left ventricular volumes.

OBJECTIVES

This study was carried out to:

1. Evaluate pFAST algorithm for processing and analysis of gated myocardial perfusion SPECT data.
2. Compare left ventricular ejection fraction determined by pFAST algorithm with those determined by QGS and ERNA.
3. Compare left ventricular volumes determined by pFAST algorithm with those determined by QGS and ERNA

MATERIALS AND METHODS

Fifty patients (28 males and 22 females) with ages between 32 to 77 years referred for assessment of myocardial perfusion and function were included in the study. All patients had angiographic evidence of coronary artery disease. Patients with cardiac arrhythmia and blocks and patients with hepatic and renal impairment were excluded from the study. Informed consent was taken from all the patients. Gated myocardial perfusion SPECT and ERNA studies were carried out on two consecutive days.

Gamma Camera:

Data were acquired on Prism 2000XP Gamma Camera (Marconi Medical, USA) interfaced with Odyssey VP computer.

Gated SPECT:

Patients were asked to come empty stomach to minimize gall bladder activity. Patients were refrained from any physical activity before the study. General and cardiovascular examination was carried out. Patients' Electrocardiogram was recorded. An intravenous canula was passed and 925 MBq of Tc99m sestamibi (Cardiolite, Dupont USA) prepared from fresh elute was injected. Data acquisition was carried at 45 minutes post injection. Gated SPECT data were acquired using 8 intervals per cardiac cycle. Acquisition was done in step and shoot manner using 30 steps, 50 seconds each step over 180 degrees, starting from 132 degrees RAO position. Data were stored on computer hard disc in 64 x 64 matrix.

SPECT Data Processing

The data were checked for any motion artifacts. Motion artifacts if any were removed using motion correction algorithm. Data were reconstructed into trans axial slices with 180 degrees filter back projection. A ramp filter was applied during reconstruction. A 3D low pass filter of order 5.0 and cut off frequency 0.21 was applied. Transverse slices were reoriented into 2.2-mm thick (1 pixel) short, horizontal long and vertical long axis slices. Short axis slices were processed on Odyssey VP computer with Cidars-Sinai QGS program for assessment of LV ejection fraction and volumes. The same short axis slices were converted to DICOM format and transferred to a networked PC. DICOM data was processed and analyzed on the PC using Sapparo Medical University's pFAST program. Left ventricular ejection fraction volumetric indices were recorded,

Equilibrium Radionuclide Angiography

In vivo labeling technique was used for RBC labeling. Amerscan stanous agent (0.3ml/Kg) was given intravenously followed by 555MBq ^{99m}TcO4 20 minutes later. Gated planar imaging was done at 24 frames per cycle in LAO 40 degrees with 10 to 20 degrees caudal tilt to get the best RV and LV separation. The images were stored in 64 x 64 matrix on computer hard disc.

The data were processed using proprietary software for multi-gated analysis on Odyssey VP for determination of ejection fraction. Left ventricular volumes were calculated using Massardeo' s method:

Volume = 1.38 M^3 x $R^{3/2}$

ED volume was calculated from the above formula and ESV was derived from EDV and ejection fraction.

STATISTICAL ANALYSIS

Linear regression analysis was performed for EF, ESV and EDV values measured with ERNA, QGS and pFAST. Correlation coefficients (r^2) and slope (y) were calculated for all three parameters.

RESULTS

There were 50 patients (28M, 22F) aged between 32 and 77 years (mean 49.1 years) in the study. All patients had angiographically proven coronary artery disease. Twenty-four patients had prior myocardial infarction while twenty-six patients presented with angina. Ejection fraction values based on ERNA varied between 15% and 78%.

Ejection fractions calculated with pFAST strongly

correlated with those calculated with ERNA (y=0.9351x, r^2 =0.8012) and QGS (y=0.9594x, r^2=0.8125). The values calculated with all three methods were almost identical (Fig.2). There was good correlation in ED volumes calculated by pFAST with those of ERNA (y = 1.2281x, r^2 = 0.7218) and QGS (1.3835, r^2=0.9087). ES volumes calculated with pFAST also correlated with ERNA values (y = 1.3482x, r^2 = 0.8512) and QGS (y=1.406x, r^2=0.934).

pFAST generally overestimated EDV by about 23 percent compared with ERNA and by 38% compared with QGS (Fig. 3). Similarly pFAST overestimated ESV by about 35 percent compared with ERNA and by 41 percent compared with QGS (Fig. 4).

DISCUSSION

The additional value of quantitative gated SPECT is well established as it provides an objective and observer independent assessment of myocardial perfusion and function. Cidars-Sinai's QGS has been thoroughly tested and validated against other diagnostic modalities. In our study, we found good correlation between QGS and ERNA values (y=0.9467, r^2=0.8596). The results of our study are identical with those of Terrence et al. who found good correlation between QGS and ERNA in patients with large perfusion defects. Our study also confirmed slight underestimation of EF with QGS compared with ERNA. These subtle differences in the ejection fraction calculated with ERNA and QGS have been ascribed to temporal artifacts created by gating at 8 intervals per cycle for QGS compared with 24 intervals per cycle for ERNA.

There is no available pFAST data to compare our values determined with this software. In our study, EF, ESV and LVDV calculated with pFAST correlated with those of ERNA and QGS. The EF values calculated by pFAST showed excellent correlation with those of QGS and ERNA. As far as EDV and ESV determination is concerned, pFAST values showed linear correlation with QGS and ERNA but consistently overestimated these volumes compared with QGS and ERNA. This may be due to the difference in the edge detection algorithms used. There is need for further improvement in the algorithm before pFAST is used for routine clinical work.

Conclusions

pFAST is highly reliable for assessment of left ventricular ejection fraction but it overestimates left ventricular volumes compared with QGS and radionuclide ventriculography .

Fig. 1: pFAST gated SPECT analysis interface

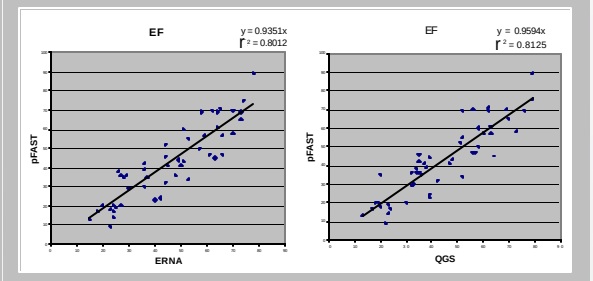

Fig. 2: Correlation of pFAST ejection fraction with those of ERNA and QGS

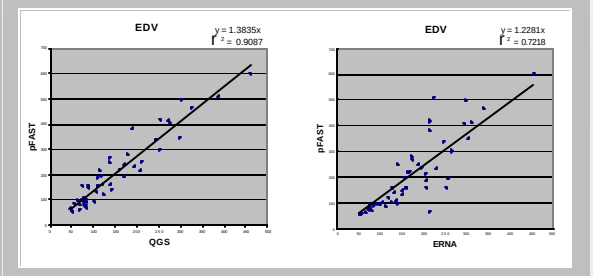

Fig 3: Correlation of pFAST EDV with those of ERNA and QGS

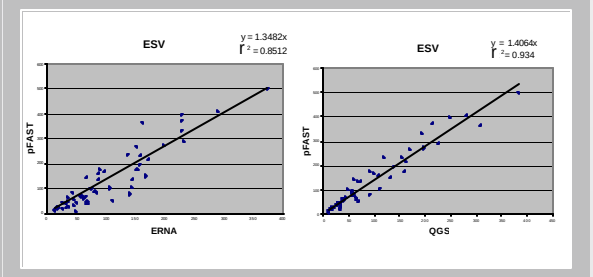

Fig 4: Correlation pFAST ESV with those of ERNA and QGS

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