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Original Article

Comparison of CSMC (Cedar Sinai Medical Center) QGS/QPS (Quantitative Gated SPECT/Quantitative Perfusion SPECT) and INVIA-4 Dimension Myocardial SPECT Softwares for Quantitative Analysis of Left Ventricular Perfusion and Function in Gated Myocardial SPECT Scintigraphy

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ABSTRACT

Objective: To compare left ventricular parameters using Quantitative Perfusion SPECT / Quantitative Gated SPECT (QPS / QGS) and 4 Dimension-Myocardial SPECT (4-DM) softwares.

Study Designs: Analytical Cross Sectional study

Place and Duration of Study: Nuclear Medical Centre, Armed Forces Institute of Pathology Rawalpindi, Pakistan from Jun 2022 to Jun 2023.

Methodology: One hundred and thirty seven patients with suspicion of coronary artery disease underwent myocardial perfusion scan during study duration. The patients underwent stress and rest gated SPECT imaging using a single day protocol. All the images were processed using QGS / QPS and 4-DM softwares separately and left ventricular parameters including Summed Stress Score (SSS), Summed Rest Score (SRS), Summed Difference Score (SDS), End Diastolic Volume (EDV), End Systolic Volume (ESV) and Ejection Fraction (EF) were calculated. Mean values and relationship between both softwares were calculated.

Results: Out of 137 patients, 80(58.4%) were men and 57(41.6%) were women with mean age of 56.29±15.17 years. The mean SSS, SRS, SDS, EDV, ESV and EF by QGS was 9.83±8.08, 6.24±6.01, 2.54±2.18, 93.94±42.73 ml, 48.04±38.16 ml and 55.94±18.06 %. While by 4-DM was 9.07±7.41, 6.72±6.39, 2.84±2.51, 97.64±43.46 ml, 45.02±40.29 ml, 61.59±18.36 % respectively. All the left ventricular parameters including SSS, SRS, SDS, EDV, ESV and EF as measured by both softwares showed substantial variation with a *p*-value of <0.001 suggesting significance statistical difference.

Conclusions: The left ventricular parameters assessed by both softwares differ significantly, so both softwares should not be used interchangeably for a single patient.

Keywords: Gated myocardial SPECT scintigraphy, Left ventricular parameters, QGS, QPS, 4DM.

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INTRODUCTION

Cardiovascular diseases are the leading cause of death attributing to almost one-third of deaths worldwide i.e., almost nine million per year.[1] Among these, prevalence of ischemic heart disease (IHD) is the much more. Risk factors for cardiovascular diseases are diabetes, hypertension, dyslipidemia, obesity, smoking along with other health, social and behavioral factors.[2,3] Multiple modalities like echocardiography, cardiovascular magnetic resonance (CMR) and computed tomography (CT) or gated blood pool studies and gated SPECT studies are well-known techniques in cardiology.[4,5,6]

Among these different imaging modalities, gated myocardial perfusion imaging (MPI) with SPECT is most used imaging procedure in the analysis and risk stratification of patients with coronary artery disease.[7] However gated SPECT has been comprehensively used for the assessment of perfusion, yet in addition to LV functions in patients with known or suspected ischemic heart disease.[8] MPI produces data on myocardial perfusion and left ventricle (LV) volumes.[9,10] Two generally used softwares for quantification of left ventricle perfusion and functions are Quantitative Perfusion SPECT (QGS/QPS), Cedars-Sinai Medical Center, Los Angeles, USA) and 4 Dimension Myocardial SPECT (4-DM, University of Michigan, Ann Arbor, USA).

Both softwares are extensively studied in evaluating left ventricular volumes and functional parameters against a gold standard. Yet it was found that if both programs are simultaneously applied to same patients, significant difference was observed for left ventricular parameters between both software. Keeping this perspective in mind we conducted this

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study to calculate mean values and correlate left ventricular volumes and functional parameters including Summed Stress Score (SSS), Summed Rest Score (SRS), Summed Difference Score (SDS) and function as left ventricular ejection fraction (LVEF), End Diastolic Volume EDV and End Systolic Volume (ESV) between both softwares

METHODOLOGY

This analytical cross sectional study was conducted at Nuclear Medical Centre, Armed Forces Institute of Pathology, Pakistan from June 2022-June 2023 over a period of one year. Study protocol was approved from IRB before start of the study (FC-NMC20-1/READ-IRB/22/1452). Sample size was determined using WHO sample size calculator with margin of error 8 %, probability in previous studies prevalence 0.65 and confidence interval 95% which came out to be 137.[11] Patients were selected by nonprobability convenient sampling technique. Informed written consent was obtained from all participants.

Inclusion Criteria: All patients with suspected coronary artery disease referred for myocardial perfusion scan were included in our study.

Exclusion Criteria: Patients who had fixed perfusion defect on Myocardial Perfusion scan, significant arrhythmias, symptoms of angina, dilated cardiomyopathy (DCM) and congestive heart failure were excluded from our study.

All patients went through stress/rest Gated SPECT imaging using a single day protocol. Resting Gated SPECT scintigraphy was done first followed by stress Gated SPECT scintigraphy. G-SPECT scintigraphy was performed in the supine position by using dual head gamma-camera – cardiac Cor Cam Gamma Camera System (DDD Diagnostic Denmark). Camera was equipped with low energy high-resolution (LEHR) collimators. Sixty four views over 180 0 orbit were obtained from RAO 450 to LPO 1350 with a zoom factor of 1.45 & at the rate of 25 sec per view and 16 frames per cardiac cycle. Acquired images were stored in matrix having size of 64 x 64 in the computer. Butterworth filters (cutoff = 0.5 of Nyquist frequency, power = 5.0) for gated tomographic images were used. Ramp filtering was done in the trans axial plane. The transverse images were re-arranged into three sets of orthogonal slices i.e. short axis (SA), horizontal long axis (HLA) and vertical long axis (VLA), for display and interpretation. These manipulations were performed on Segami Oasis V1.9 software. Input data were processed on both QGS/QPS and 4-DM software, both of which were previously installed on the computer system. Images were assessed by visual as well as semi-quantification method. The 20 segment five-point scoring system (0 = normal perfusion, 1 = mildly reduced perfusion, 2 = moderately reduced perfusion, 3 = severely reduced perfusion, 4 = absent perfusion) was employed for quantification of myocardial perfusion. The SSS and SRS were calculated by adding the different segment scores obtained from the study. The SDS was calculated by subtracting SRS from the SSS, which indicates degree of ischemia.

All data including patient demographic data and software parameters were entered and analyzed by statistical package for the social sciences (SPSS version 20.1). Quantitative data was presented as Mean ± SD and categorical data was presented as frequency and percentages. To compare SSS, SRS, SDS and function as left ventricular ejection fraction (LVEF), EDV and ESV between both softwares independent Sample t test was applied. Correlation Analysis was used to find out the realtionship of EF (%age) between QGS & 4DM, and EDV (ml) between GQS & 4DM. The p value of ≤ 0.05 was considered significant.

RESULTS

Out of 137 patients, 80(58.4%) were men and 57(41.6%) were women, ranging in age between 27 and 86 years (mean age: 56.29±15.17 years). 57(41.6%) had hypertension, 59(43.1%) had diabetes, 68(49.6%) had hyperlipidemia, 47(34.3%) had chronic kidney disease, 43(31.4%) had congestive heart failure, 38(27.7%) had myocardial infarction, 44(32.1%) had COPD as significant risk factors shown in Table-I. The mean SSS by QGS was 9.83±8.08 and by 4-DM was 9.07±7.41. The mean SRS by QGS was 6.24±6.01 and by 4-DM was 6.72±6.39. The means SDS by QGS was 2.54±2.18 and by 4-DM was 2.84±2.51. The mean EDV by QGS was 93.94±42.73 ml and by 4-DM was 97.64±43.46 ml. The mean ESV by QGS was 48.04±38.16 ml and by 4-DM was 45.02±40.29 ml. The mean EF by QGS was 55.94±18.06 % and by 4-DM was 61.59±18.36 % as shown in Table-II.

SSS, SRS, SDS, EDV, ESV and EF as measured by both softwares show substantial variation with a *p*-value of <0.001 suggesting significance statistical difference as shown in Table-II. The linear correlations between EF as calculated by 4DM and QGS/QPS shows strong correlation with r value of 0.88 as shown in Figure-1. Similarly, EDV values calculated by 4DM

and QGS/QPS were strongly correlated with r value of 0.91 as shown in Figure-2.

Table-I: Baseline Characteristics of Patients (n=137)

Characteristics	Values
Age, years (Mean ± SD)	56.29±15.17
Gender n (%age)	
Male	80(58.4%)
Female	57(41.6%)
Comorbid n (%age)	
HTN	57(41.6%)
DM	59(43.1%)
Hyperlipidemia	68(49.6%)
CKD	47(34.3%)
CHF	43(31.4%)
MI	38(27.7%)
COPD	44(32.1%)

HTN: Hypertension, DM: Diabetes mellitus, CKD: Chronic kidney disease, CHF: Congestive heart failure, MI: Myocardial infarction, COPD: Chronic obstructive pulmonary disease.

Table-II: Comparison Of Left Ventricular Parameters Among Softwares (n=137)

Parameters	Software		*p*-value
	QGS (n=137)	4DM (n=137)	
SSS	9.83±8.08	9.07±7.41	0.005
SRS	6.24±6.01	6.72±6.39	<0.001
SDS	2.54±2.18	2.84±2.51	0.014
EDV	93.94±42.73 ml	97.64±43.46 ml	<0.001
ESV	48.04±38.16 ml	45.02±40.29 ml	<0.001
EF	55.94±18.06 %	61.59±18.36 %	<0.001

SSS: Summed Stress Score, SRS: Summed Rest Score, SDS: Summed Difference Score, EDV: End Diastolic Volume, ESV: End Systolic Volume, EF: Ejection Fraction.

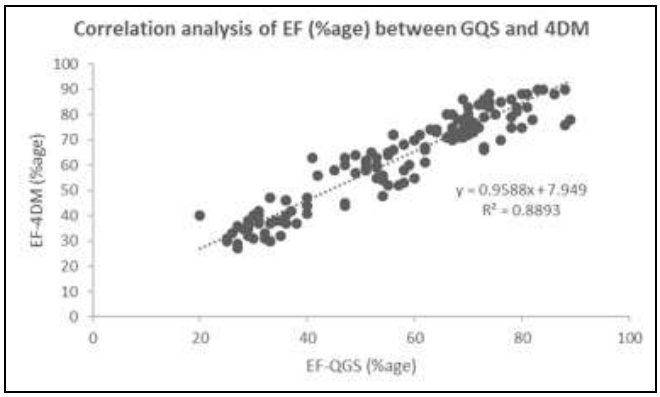

Figure-1: Correlation Analysis of EF (%age) between QGS and 4DM (n=137)

DISCUSSION

In this study the quantitative analysis of left ventricular perfusion parameters, including the SSS, SRS and SDS, revealed a significant difference in SSS, SRS, and SDS values between the two software packages (p<0.001), indicating that the software choice impacts the quantification of left ventricular perfusion parameters. Knollmann et al. compared SSS and SRS of Normal Databases and found that SSS mean values were 9.4±10.3 and SRS mean values were 5.8±9.7 for QPS. Similarly, SSS mean values were 8.2±8.7 and SRS mean values were 6.2±7.8 for 4D-M which are comparable to results found in our study.[12]

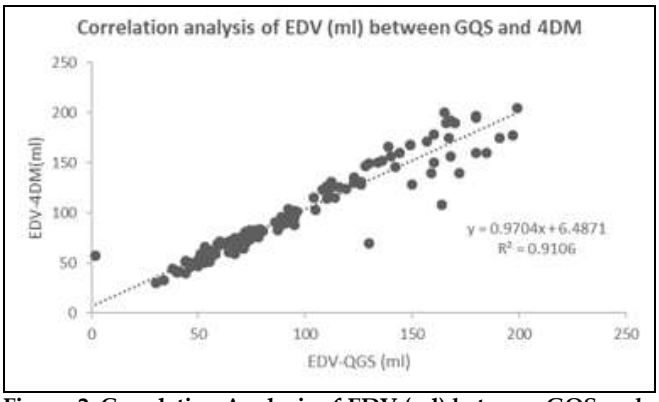

Figure-2: Correlation Analysis of EDV (ml) between GQS and 4DM

Regarding left ventricular function parameters, the mean end-diastolic volume (EDV) measured by QGS and 4-DM were 93.94±42.73 ml and 97.64±43.46 ml, respectively, while the mean end-systolic volume (ESV) was 48.04±38.16 ml and 45.02±40.29 ml, respectively. The mean ejection fraction (EF) obtained with QGS and 4-DM were 55.94±18.06 % and 61.59±18.36 %, respectively. Similar to the perfusion parameters, significant differences were observed in the EDV, ESV, and EF measurements between the two software packages (p<0.001). Lavender et al in their research found that 4DM-SPECT produces EF estimates up to 15% above or 12% below the QGS estimate.[13] Nilüfer et al. measured EDV, ESV and EF for 109 females with suspicion of coronary artery disease but normal MPS and found a difference of 9% between EF calculated with 4-DM and QGS.[14] Main reason being that these algorithms produce different results and behave differently from one another and should not be used interchangeably.[15]

Major difference between the QGS and 4DM-SPECT software is valve plane determination criteria. In QGS/QPS, valve plane refers to that surface that intersects the basal myocardial points resulting in an oblique valve plane tilting towards septal myocardium.[16] Whereas in 4DM-SPECT, the valve plane is perpendicular to the long axis of the heart.[17,18]

These findings suggest that there is a discrepancy in the quantification of both perfusion and function parameters when using the CSMC (QGS/QPS) and INVIA-4DM software packages. The observed differences in the mean values can be attributed to variations in the algorithms, segmentation techniques, and image processing algorithms employed by the software packages.

At the same time, there are many other parameters that can lead to significant differences in estimation of functional parameters including soft tissue attenuation, obesity and chest circumference of the patient. Individuals with greater body mass index (BMI) may have decreased and heterogeneous myocardial count densities, which leads to underestimation of EF.[19] Moreover, the results of these types of studies also depends on various physiological differences that exist between different sexes and that are not fully understood up-till now.

CONCLUSION

The left ventricular parameters assessed by both softwares differ significantly, so both softwares should not be used interchangeably for a single patient.

Conflict of Interest: None.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

ZS & FH: Data acquisition, data analysis, critical review, approval of the final version to be published.

MA & MA: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

AM & HS: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

REFERENCES

1. Khan MA, Hashim MJ, Mustafa H, Baniyas MY, Al Suwaidi SK, AlKatheeri R, et al. Global epidemiology of ischemic heart disease: results from the global burden of disease study. Cureus 2020; 12(7). http://doi.org/10.7759/cureus.9349
2. Timmis A, Vardas P, Townsend N, Torbica A, Katus H, De Smedt D, et al. European Society of Cardiology: cardiovascular disease statistics 2021. Eur Heart J 2022; 43(8): 716-799. http://doi.org/10.1093/ehjqcco/qcac014
3. Safiri S, Karamzad N, Singh K, Carson-Chahhoud K, Adams C, Nejadghaderi SA, et al. Burden of ischemic heart disease and its attributable risk factors in 204 countries and territories, 1990–2019. Eur J Prev Cardiol 2022; 29(2): 420-431. https://doi.org/10.1093/eurjpc/zwab213
4. Secinaro A, Ait-Ali L, Curione D, Clemente A, Gaeta A, Giovagnoni A, et al. Recommendations for cardiovascular magnetic resonance and computed tomography in congenital heart disease: a consensus paper from the CMR/CCT working group of the Italian Society of Pediatric Cardiology (SICP) and the Italian College of Cardiac Radiology endorsed by the Italian Society of Medical and Interventional Radiology (SIRM) Part I. La Radiologia Medica 2022; 127(7): 788-802. http://doi.org/10.1007/s11547-022-01490-9
5. Printezi MI, Yousif LI, Kamphuis JA, van Laake LW, Cramer MJ, Hobbelink MG, et al. LVEF by Multigated Acquisition Scan Compared to Other Imaging Modalities in Cardio-Oncology: a Systematic Review. Current Heart Failure Reports 2022; 19(3): 136-145. https://doi.org/10.1007/s11897-022-00544-3
6. Reeves RA, Halpern EJ, Rao VM. Cardiac imaging trends from 2010 to 2019 in the Medicare population. Radiol Cardiothorac Imaging 2021; 3(5): e210156. https://doi.org/10.1148/ryct.2021210156
7. Garcia EV, Slomka P, Moody JB, Germano G, Ficaro EP. Quantitative clinical nuclear cardiology, Part 1: Established applications. J Nuc Cardiol 2020; 27: 189-201. http://doi.org/10.1007/s12350-019-01906-6
8. Papandrianos NI, Feleki A, Moustakidis S, Papageorgiou EI, Apostolopoulos ID, Apostolopoulos DJ. An explainable classification method of SPECT myocardial perfusion images in nuclear cardiology using deep learning and grad-CAM. Applied Sciences 2022; 12(15) 7592. http://doi.org/10.3390/app12157592
9. Wang T, Lei Y, Tang H, He Z, Castillo R, Wang C, et al. A learning-based automatic segmentation and quantification method on left ventricle in gated myocardial perfusion SPECT imaging: A feasibility study. J Nucl Cardiol 2020; 27: 976-987. https://doi.org/10.1007/s12350-019-01594-2
10. Al-Shammari AF, Afzal U. Comparison of totally automated and manual processing for calculation of left ventricular volumes and ejection fraction using gated myocardial perfusion SPECT. Cardiometry 2022; 1(22): 136-142 http://doi.org/10.18137/cardiometry.2022.22.136142
11. Nichols K, Santana CA, Folks R, Krawczynska E, Cooke CD, Faber TL, et al. Comparison between ECTb and QGS for assessment of left ventricular function from gated myocardial perfusion SPECT. J Nucl Cardiol 2002; 9(3): 285-293. http://doi.org/10.1067/mnc.2002.121449
12. Knollmann D, Knebel I, Koch KC, Gebhard M, Krohn T, Buell U, et al. Comparison of SSS and SRS calculated from normal databases provided by QPS and 4D-MSPECT manufacturers and from identical institutional normals. Eur J Nucl Med Mol Imaging 2008; 35: 311-318. http://doi.org/10.1007/s00259-007-0600-5
13. Lavender FM, Meades RT, Al-Nahhas A, Nijran KS. Factors affecting the measurement of left ventricular ejection fraction in myocardial perfusion imaging. Nucl Med Commun 2009; 30(5): 350-355 http://doi.org/10.1097/MNM.0b013e328329d9ab
14. Nilüfer bicakci. Normal gated miyokardiyal perfüzyon spect' e sahip kadin hastalarda sol ventrikül ejeksiyon fraksiyonu ve volüm değerleri: 4D-MSPECT ve siemens ICON®-QGS ile karşilaştirma. J Contemp Med 2018; 8(3): 239-244 http://doi.org/10.16899/gopctd.435461
15. Lum DP, Coel MN. Comparison of automatic quantification software for the measurement of ventricular volume and ejection fraction in gated myocardial perfusion SPECT. Nucl Med Commun 2003; 24(3): 259-266. https://doi.org/10.1097/00006231-200303000-00005

16. Germano G, Kiat H, Kavanagh PB, Moriel M, Mazzanti M, Su HT, et al. Automatic quantification of ejection fraction from gated myocardial perfusion SPECT. J Nucl Med 1995; 36: 2138–2147 http://doi.org/10.1016/s1071-3581(99)90022-3
17. Stegger L, Lipke CS, Kies P, Nowak B, Schober O, Buell U, et al. Quantification of left ventricular volumes and ejection fraction from gated (99m)Tc-MIBI SPECT: validation of an elastic surface model approach in comparison to cardiac magnetic resonance imaging, 4D-MSPECT and QGS. Eur J Nucl Med Mol Imaging 2007; 34: 900–909. http://doi.org/10.1007/s00259-006-0322-0
18. Faber TL, Stokely EM, Peshock RM, Corbett JR. A model-based four-dimensional left ventricular surface detector. IEEE Trans Med Imaging 1991; 10(3): 321-329. http://doi.org/10.1109/42.97581
19. Achtert AD, King MA, Dahlberg ST, Hendrik Pretorius P, LaCroix KJ, Tsui BM. An investigation of the estimation of ejection fractions and cardiac volumes by a quantitative gated SPECT software package in simulated gated SPECT images. J Nucl Cardiol 1998; 5(2): 144-152. http://doi.org/10.1016/s1071-3581(98)90197-0