Inter- and intra-operator reproducibility of gated myocardial perfusion SPECT LVEF using QGS

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Foot line: Inter- and intra-operator reproducibility in Gated SPECT

ABSTRACT

INTRODUCTION: Validation studies for QGS have focussed on the correlation between quantitative measurements of gated SPECT myocardial perfusion imaging and the various modalities providing functional parameters. A detailed investigation of the inter- and intra-operator reproducibility of LVEF is yet to be reported in the literature.

METHODOLOGY: Each of 50 gated SPECT data sets (25 rest and 25 stress) were each reconstructed and quantitated with automated QGS to determine the LVEF by two independent, experienced technologist operators blinded to previous results and those of the other operator. The 50 data sets were re-analysed by the same operators not less than 80 days after the initial data analysis.

RESULTS: Combined rest and stress data for the two independent operators showed a mean LVEF of 49.46% for the first analysis and 49.56% for the second analysis. No statistically significant difference was noted in the mean difference of 0.10% (P = 0.94) and no statistically significant difference was noted between matched pairs (P = 0.49). Excellent correlation was noted with a correlation coefficient of 0.994. A mean LVEF of 49.46% was shown for the first operator and 49.46 for the second operator. No statistically significant difference was noted in the mean difference of 0.00% (P = 1.00) and no statistically significant difference was noted between matched pairs (P = 1.00). Excellent correlation was noted with a correlation coefficient of 0.994.

CONCLUSION: QGS has been shown to demonstrate excellent reproducibility. Furthermore, the QGS determined LVEF is robust temporally allowing raw data to be accurately re-analysed after a period of time has elapsed.

Key words: gated SPECT, reproducibility, inter, intra, operator, LVEF

INTRODUCTION

The high count density of $^{99m}$Tc based myocardial perfusion studies allows SPECT images to be synchronised to the patients electrocardiogram (gated) because they maintain adequate count density in individual cardiac frames (intervals). This feature, in conjunction with acceptable spatial and contrast resolution, allows simultaneous assessment of myocardial perfusion and ventricular function.\(^1\)

There are a number of advantages of gating a myocardial perfusion SPECT study, including:

- The ability to obtain increased spatial resolution by removing the blurring of the contracting myocardium. This allows evaluation of the end diastolic image for the detection of small perfusion abnormalities.\(^2,3\)
- The potential for wall motion and thickening to differentiate pathology from artefact.\(^4\) As a result, gated myocardial perfusion SPECT improves overall specificity for the detection of CAD.\(^5,6\)
- The assessment of global and regional left ventricular function. The left ventricular ejection fraction (LVEF) is calculated to provide global evaluation and wall motion while wall thickening are used to evaluate regional function.\(^7\)

A variety of software packages are available for performing quantitation in gated myocardial perfusion SPECT, one of the most commonly used is the quantitative gated SPECT (QGS) software (Cedars Sinai Medical Centre, Los Angles, CA).\(^1\) Validation studies for QGS have focussed on the correlation between quantitative measurements of gated SPECT myocardial perfusion imaging and the various modalities providing functional parameters.

This report details the intra-operator and inter-operator reproducibility (systematic error) of the LVEF determined by reconstruction and QGS analysis of gated myocardial perfusion SPECT.

METHODOLOGY

This study was retrospective using a repeat-measures design (within-subject design). Twenty five myocardial perfusion SPECT studies, each with both a gated rest and gated stress study, were analysed using QGS software and using parameters prescribed by the software package. All patients in the study population followed a two day protocol with rest / stress performed on separate days. All used 740 MBq of $^{99m}$Tc tetrofosmin (Nycomed-Amersham, Amsterdam). A triple detector system was used to
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acquire all patient data. All data acquisitions employed low energy, high resolution collimation with step and shoot mode, elliptical orbits and a 64 matrix. The zoom was 1.23 and projections were acquired at 3 degree intervals for 20 seconds per projection to provide a total acquisition time of 15 minutes. The patients were supine. An eight-interval gated SPECT acquisition was performed.

Each of 50 gated SPECT data sets were reconstructed and re-sliced according to QGS software recommendations and analysed with automated QGS to determine the LVEF by two independent, experienced technologist operators blinded to previous results. The 50 data sets were re-analysed by the same operators not less than 90 days later. Data sets requiring manual intervention in the QGS analysis would have been excluded from the study, although none were encountered.

The statistical significance for continuous data was calculated using Student’s t test. A P value less than 0.05 was considered significant. Inter- and intra-observer correlation was evaluated with Chi-Square analysis. Bland-Altman analysis and the matched pairs t test were used to assess agreement between pairs.

Table 1: Summary of intra-operator reproducibility results.

<table>
<thead>
<tr>
<th>Operator</th>
<th>Study</th>
<th>Mean LVEF Analysis 1</th>
<th>Mean LVEF Analysis 2</th>
<th>Mean Difference</th>
<th>Correlation Coefficient</th>
<th>Match Pair t Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rest</td>
<td>50.24%</td>
<td>50.32%</td>
<td>0.08</td>
<td>0.995</td>
<td>0.75</td>
</tr>
<tr>
<td>1</td>
<td>Stress</td>
<td>48.68%</td>
<td>48.84%</td>
<td>0.16</td>
<td>0.996</td>
<td>0.46</td>
</tr>
<tr>
<td>2</td>
<td>Rest</td>
<td>50.40%</td>
<td>50.52%</td>
<td>0.12</td>
<td>0.993</td>
<td>0.70</td>
</tr>
<tr>
<td>2</td>
<td>Stress</td>
<td>48.52%</td>
<td>48.56%</td>
<td>0.04</td>
<td>0.991</td>
<td>0.92</td>
</tr>
<tr>
<td>1 &amp; 2</td>
<td>Both</td>
<td>49.46%</td>
<td>49.56%</td>
<td>0.10</td>
<td>0.994</td>
<td>0.49</td>
</tr>
</tbody>
</table>

Of the 25 patients, 15 were male and 10 were female. The mean patient age was 64.5 years with a range of 47 to 85 years. The mean time between observations for operator one was 134 days with a range of 83 to 173 days. The mean time between observations for operator two was 173 days with a range of 171 to 176 days.

The intra-operator reproducibility stratified to rest studies and stress studies have been summarised in table 1 for each observer. No statistically significant differences were noted in the mean difference between observations and no statistically significant difference was noted between matched pairs. Combining both rest and stress studies for the two independent operators showed a mean LVEF of 49.46% for the first analysis and 49.56% for the second analysis. No statistically significant difference was noted in the mean difference of 0.10% (P = 0.94) and no statistically significant difference was noted between matched pairs (P = 0.49). Excellent correlation was noted with a correlation coefficient of 0.994. This was further supported by Bland-Altman analysis, with 96% of data points being contained within the 95% limits of agreement (Fig. 1).

The inter-operator reproducibility stratified to rest studies and stress studies have been summarised in table 2. No statistically significant differences were noted in the mean difference between observers and no statistically significant difference was noted between matched pairs. Since the intra-operator reproducibility was shown to be excellent, only the first observations of each operator were utilised in this inter-operator reproducibility analysis.

Combining both rest and stress studies showed a mean LVEF of 49.46% for the first operator and 49.46 for the second operator. No statistically significant difference was noted in the mean difference of 0.00% (P = 1.00) and no statistically significant difference was noted between matched pairs (P = 1.00). Excellent correlation was noted with a correlation coefficient of 0.994. Bland-Altman analysis, however, only demonstrated 92% of data points being contained within the 95% limits of agreement (Fig. 2).

Discussion/Conclusion

QGS has been shown to demonstrate excellent reproducibility with no evidence of significant systematic error in the reconstruction, re-slice and quantitation process. The QGS determined LVEF is robust to variations in operator and, thus, one can expect to observe

Figure 1 (left): Bland-Altman analysis of the mean of the first and second LVEF (both observers and both stress and rest studies) versus difference between the two observations shows no trend. The mean difference in LVEF between the two observations (0.10) is indicated by the solid horizontal line while the outer solid lines represent the 95% limits of agreement. The inner dotted lines represent the 95% CI of the LVEF difference.
matching results comparing those of the technologist during the initial data processing to those of the physician reporting the study on a remote work station. Furthermore, the QGS determined LVEF is robust temporally allowing raw data to be accurately re-analysed after a period of time has elapsed. One needs to consider that this evaluation did not simply evaluate the reproducibility of the QGS software but also of the reconstruction process that provides the short axis data for QGS analysis and, thus, the QGS software is robust to variations one might expect in the reconstruction processes between operators or over time (e.g. re-slice orientation).

Table 2: Summary of inter-operator reproducibility results.

<table>
<thead>
<tr>
<th>Study</th>
<th>Mean LVEF Operator 1</th>
<th>Mean LVEF Operator 2</th>
<th>Mean Difference</th>
<th>Correlation Coefficient</th>
<th>Match Pair t Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest</td>
<td>50.24%</td>
<td>50.40%</td>
<td>0.16</td>
<td>0.993</td>
<td>0.63</td>
</tr>
<tr>
<td>Stress</td>
<td>48.68%</td>
<td>48.52%</td>
<td>-0.16</td>
<td>0.995</td>
<td>0.53</td>
</tr>
<tr>
<td>Both</td>
<td>49.46%</td>
<td>49.46%</td>
<td>0.00</td>
<td>0.994</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Figure 2 (left):
Bland-Altman analysis of the mean of the first and second operators LVEF versus difference between the two observers shows no trend. The mean difference in LVEF between the two observations (0.00) is indicated by the solid horizontal line while the outer solid lines represent the 95% limits of agreement. The inner dotted lines represent the 95% CI of the LVEF difference.

REFERENCES