Electrocardiogram-gated single-photon emission computed tomography versus cardiac magnetic resonance imaging for the assessment of left ventricular volumes and ejection fraction: a meta-analysis

Ioannidis J P, Trikalinos T A, Danias P G

Authors' objectives
To evaluate the accuracy of electrocardiogram (ECG)-gated single-photon emission computed tomography (SPECT) for the assessment of left ventricular (LV) end-diastolic volume (EDV), end-systolic volume (ESV) and ejection fraction (EF) compared with the 'gold' standard of cardiac magnetic resonance imaging (MRI).

Searching
MEDLINE and EMBASE were searched (last search updated December 2001); the search terms were listed. In addition, the bibliographies of retrieved articles and reviews were screened and experts in the field were contacted for additional studies. Meeting abstracts were excluded. It was unclear whether any language restrictions were applied, or whether unpublished studies were included.

Study selection
Study designs of evaluations included in the review
No inclusion criteria relating to the study design were specified.

Specific interventions included in the review
Studies of ECG-gated SPECT (using technetium-99m-labelled sestamibi or tetrofosmin or thallium-201) were eligible for inclusion. Studies were eligible for inclusion regardless of whether the images were acquired at rest or after stress, regardless of the technical parameters used for either test, and regardless of the algorithm used to calculate EF and LV. The included studies used the radioisotopes sestamibi or tetrofosmin.

Reference standard test against which the new test was compared
Studies that included cardiac MRI as the reference standard were eligible for inclusion.

Participants included in the review
Studies were eligible regardless of whether they referred to healthy individuals or patients with suspected or proven disease. Phantom only and animal studies were excluded. The proportion of men in the included studies ranged from 67 to 95%, while the proportion of patients with prior myocardial infarction ranged from 42 to 100%.

Outcomes assessed in the review
No inclusion criteria relating to the outcomes were specified. The outcomes reported in the review were correlation coefficients and regression equations for the correlation between ECG-gated SPECT and cardiac MRI, the proportion of patients in whom a defined difference in measurement between ECG-gated SPECT and cardiac MRI was observed, and estimates of sensitivity and specificity.

How were decisions on the relevance of primary studies made?
The authors did not state how the papers were selected for the review, or how many reviewers performed the selection.

Assessment of study quality
Validity was not formally assessed. However, details on the blinding of evaluators, timing between the index test and reference standard, the number of patients evaluated with either technique, and reasons for any non-evaluations were extracted.
Data extraction
The data extraction was performed in duplicate by two independent investigators. Any discrepancies were resolved by consensus and by using a third investigator as arbiter. Details on the items of data extracted from the primary studies were reported in the paper. For each patient, the authors recorded the EDV, ESV and EF with each imaging modality. When numerical data were not given directly, relevant information was extracted from graphs or by communication with study investigators.

When ECG-gated SPECT measurements had been corrected by a phantom-study correction factor, the analysis was performed with both uncorrected and corrected values. The sensitivity, specificity and overall misclassification rate of ECG-gated SPECT measurements were calculated in terms of classifying patients as having EF greater than 40% versus less than or equal to 40%, separately for each study. The authors verified that regression analyses from the data of each study replicated the regression coefficients provided in the respective published report, typically within 1%.

Methods of synthesis
How were the studies combined?
The main analysis involved pooling individual patient data across studies. Scatter plots were generated with ECG-gated SPECT measurements on the y-axis and cardiac MRI measurements on the x-axis. Pearson correlation coefficients (r) were estimated, and linear regression was applied to each set of ECG-gated SPECT data versus cardiac MRI data. Unweighted least-squares methods were used to estimate the intercept and slope coefficients and 95% confidence intervals (CIs). Coefficients of determination and standard errors of these estimates were calculated for each regression.

The proportion of cases and 95% CIs for differences of at least 30 mL in the EDV, at least 20 mL in the ESV, and at least 5% or 10% in the EF between the two methods were calculated. Both simple pooling and weighted random-effects modelling were used to estimate the proportions.

Sensitivity and specificity estimates were pooled by simple pooling and by random-effects pooling across studies. A summary receiver operating characteristic curve approach was not used, as studies tended to operate in the same area of the curve.

How were differences between studies investigated?
The authors estimated correlation coefficients and regression slopes for individual studies and examined whether these were heterogeneous. Bland-Altman plots and regressions were used to examine whether the difference in the two measurements varied at different levels of the EDV, ESV or EF (see Other Publications of Related Interest).

Between-study heterogeneity in the proportions exceeding the differences outlined above was assessed using exact inference for nx2 tables, where n was the number of studies.

Separate analyses were conducted for subgroups defined on the basis of low EF (less than or equal to 40% by ECG-gated SPECT) compared with normal or intermediate EF, normal compared with low ESV (70 mL cut-off by ECG-gated SPECT) and blinding parameters. These subgroups were assessed to investigate whether there were differences in the concordance of the two methods, as expressed by the metrics outlined already.

Results of the review
Eight studies were included; the number of patients not reported.

Correlation between ECG-gated SPECT and cardiac MRI.

There was excellent correlation between ECG-gated SPECT and cardiac MRI for EDV (r=0.89), ESV (r=0.92) and EF (r=0.87); P<0.001 for all correlation coefficients. The estimated regression equations suggested that ECG-gated SPECT tends to overestimate EDV and ESV compared with cardiac MRI for values less than 89 mL, while it tends to overestimate EDV and ESV at higher volumes. On average, ECG-gated SPECT tends to overestimate EF when EF is very low (less than 31%) and underestimate EF when ventricular function is preserved.
Rates of discrepancy.

For individual patients, the rates were:

- 37% (95% CI: 26, 50) for discrepancies of at least 30 mL in EDV;
- 35% (95% CI: 23, 49) for discrepancies of at least 20 mL in ESV;
- 52% (95% CI: 37, 63) for discrepancies of at least 5% in EF; and
- 23% (95% CI: 11, 42) for discrepancies of at least 10% in EF.

Use of ECG-gated SPECT in identifying patients with an EF of less than or equal to 40%.

The sensitivity ranged from 50 to 100% and the specificity ranged from 75 to 100%. When using a random-effects method to pool the studies, the sensitivity was 83% (95% CI: 69, 92) and the specificity was 84% (95% CI: 75, 90).

Authors' conclusions

ECG-gated SPECT measurements of EDV, ESV and EF show high correlation with cardiac MRI measurements, but substantial errors may occur in individual patients. ECG-gated SPECT offers useful functional information, but cardiac MRI should be used when accurate measurement is required.

CRD commentary

This was a well-conducted review. The objective was clearly defined and supported by explicit inclusion criteria. The literature search was limited to two databases, but it was unclear whether any language restrictions were applied or whether attempts were made to include unpublished studies. It is therefore possible that some important studies might have been missed and the review may be subject to publication bias. Some methodological details of the review process were reported and these included appropriate attempts to minimise bias. Although some methodological details relating to the quality of the primary studies were extracted and discussed, validity was not formally assessed.

Very few details of the primary studies were tabulated, although some important details were discussed in the text. Appropriate methods were used to synthesise the study results. The authors' conclusions are supported by the results presented.

Implications of the review for practice and research

Practice: The authors stated that ECG-gated SPECT offers useful functional information, but cardiac MRI should be used when accurate measurement is required.

Research: The authors stated that further research on the accuracy of ECG-gated SPECT is required in patients with severe perfusion defects and in women, and with the contrast agent thallium-201.

Bibliographic details


PubMedID

12084609

Original Paper URL

http://content.onlinejacc.org/cgi/content/full/39/12/2059
Other publications of related interest

Indexing Status
Subject indexing assigned by NLM

MeSH
Electrocardiography; Humans; Magnetic Resonance Imaging; Stroke Volume; Tomography, Emission-Computed, Single-Photon; Ventricular Function, Left

AccessionNumber
12002001512

Date bibliographic record published
30/11/2005

Date abstract record published
30/11/2005

Record Status
This is a critical abstract of a systematic review that meets the criteria for inclusion on DARE. Each critical abstract contains a brief summary of the review methods, results and conclusions followed by a detailed critical assessment on the reliability of the review and the conclusions drawn.