Accuracy of right ventricular volumes and function determined by three-dimensional echocardiography in comparison with magnetic resonance imaging: a meta-analysis study

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CRD summary
This review concluded that three-dimensional echocardiography underestimated right ventricular cardiac volumes (end-systolic and end-diastolic volumes) and ejection fraction. The limited search and lack of an assessment of the quality of included studies means that it is difficult to determine the reliability of these conclusions.

Authors’ objectives
To assess the accuracy of determination of cardiac right ventricular volumes and function by three-dimensional (3D) echocardiography compared with magnetic resonance imaging (MRI).

Searching
MEDLINE was searched up to May 2010 for studies reported in English. Search terms were reported. References of identified studies were also checked. Only studies published in full were eligible for inclusion.

Study selection
Studies that compared the difference in right ventricular end-systolic volume, end-diastolic volume or ejection fractions between 3D echocardiography and MRI were eligible for inclusion. Studies were required to report or to permit the calculation of the mean difference and standard deviation (SD).

Included studies primarily enrolled healthy volunteers, individuals with congenital heart abnormalities, and patients with coronary heart disease or post-surgical patients. Mean ages of individuals in included studies ranged from 5.9 to 68.7 years. Most studies used an apical or some form of modified apical view for 3D echocardiography. Slice thickness ranged from 2 to 10mm (where reported). Where reported, 50% of studies used semi-automatic tracking of the endocardium and 50% used manual tracking. A number of different types of hardware and software were used, although most studies used some version of TomTec software.

Two reviewers independently assessed the papers for inclusion in the review.

Assessment of study quality
The authors did not state that they assessed validity.

Data extraction
Data were extracted to permit calculation of mean differences and their standard deviations for the outcomes of end-systolic volume, end-systolic volume and ejection fraction between the methods of 3D echocardiography and MRI. Individual patient data were extracted where possible. Where data were represented graphically, the authors estimated values.

The authors did not state how many reviewers performed the data extraction.

Methods of synthesis
Mean differences were pooled in inverse variance random-effects model analyses to calculate weighted mean differences (WMD) with 95% confidence intervals (CI). Heterogeneity was assessed using $\chi^2$ and $I^2$.

A priori subgroup analyses were performed to investigate the impact of the following factors: use of matrix-array transducers; use of a semi-automatic endocardial tracking system; mean patient age over 18 years versus under 18 years; and mean end-diastolic volume under 200mL versus over 200mL. Univariate and multivariate regression were used to further investigate the impact of these variables on outcome differences.
Bland-Altman analysis was used to assess the relationship between the values for each outcome as determined by the two technologies.

Publication bias was assessed using funnel plot analysis.

**Results of the review**
Twenty-three studies were included in the review (n=807 patients). Sample size ranged from 13 to 88 patients.

There was statistically significant underestimation of right ventricular end-systolic volume by 3D echocardiography compared with MRI (WMD -5.5mL, 95% CI -7.6 to -3.4; $I^2=91\%$). Right ventricular end-diastolic volume was also significantly underestimated (WMD -13.9mL, 95% CI -17.7 to -10.1; $I^2=96\%$), as was ejection fraction (WMD -0.9%, 95% CI -1.8 to -0.1; $I^2=80\%$).

Subgroup analyses found that there was greater underestimation of volumes in studies where the mean age of participants was below 18 years and in studies where the mean end-diastolic volume was over 200mL.

Results of regression analyses were also reported.

**Authors' conclusions**
Three-dimensional echocardiography was found to underestimate right ventricular volumes (end-systolic and end-diastolic volumes) and ejection fraction; factors which impacted this effect were identified.

**CRD commentary**
The review question was clear and some inclusion criteria were defined. However, only one database was searched and the review was restricted to published studies reported in English. These factors all make it more likely that relevant studies were missed and that publication and language biases were introduced. The authors reported using methods designed to reduce bias and error in the selection of studies, but not in the extraction of data.

No assessment of study quality was reported, which made it difficult to gauge the reliability of the evidence represented in the review. The synthesis appeared reasonable, although there were high levels of statistical heterogeneity; the influence of moderating factors was investigated.

Given the limited search and lack of quality assessment of included studies, the reliability of the authors' conclusions is unclear.

**Implications of the review for practice and research**
**Practice**: The authors stated that 3D echocardiography will continue to be an attractive modality for rapid non-invasive and replicable assessment of the right ventricle while the strategy of tracing the right ventricle endocardium is itself supported.

**Research**: The authors did not state any implications for further research studies but identified the following areas for technical development: semi-automated tracking systems, matrix-array transducers, software that can fit the irregular borders of diseased right ventricles, spatial and temporal resolution, and time for obtaining images.

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**Bibliographic details**
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