Feasibility and accuracy of 3-dimensional echocardiography for measurements of the right ventricular volumes and function in adult patients: validation with magnetic resonance imaging.

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No disclosures
Background

Right ventricle (RV)

• Complex geometry
• Outspread inflow and outflow tracts
• Several scan planes with 2-dimensional echocardiography
• Estimations of size and function
3D-echocardiography (3DE)
Endocardial delineation of RV on 3DE
Purpose

- To investigate the feasibility of full volume acquisition with three-dimensional echocardiography
- To assess the accuracy of the right ventricular volumes and function in an adult non-selected patient population – compared to cardiac magnetic resonance (CMR)
- To assess if manual correction of the semi-automatic delineation influences the accuracy
Method

- 62 patients with various cardiologic pathology
- 35 % Female, age 55 ± 16 (18-83)
- BMI 26 ± 4 (17-35)
- 3DE and CMR
Method

- 3DE recorded with Philips Sonos 7500 and iE3
  - Matrix array transducer
  - ECG-gating
  - Breath-hold technique
  - Full volume
  - 4-7 heart cycles
- Tomtec 4D RV-Function©
Delineation of RV on 3DE

Uncorrected

Manually corrected

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CMR

- 1.5T Philips Intera MR scanner
  - Cine images: parallel short-axis and transversal planes
  - ECG-gating
  - End-expiratory apnoe
  - Voxel size: 1.5 x 1.5 x 8 mm
- Segment 1.8 (www.segment.se)
CMR short axis view
CMR transversal view
Endocardial delineation on CMR

Short-axis

Transversal

EDV

ESV
Results

- 85% were feasible for 3DE interpretation
- Interpretation time:
  - 3DE corrected: 13 min 37 sec ± 4 min 7 sec
  - 3DE uncorrected: 3 min 44 sec ± 1 min 36 sec*
  - CMR transversal: 11 min 34 sec ± 5 min 35 sec**
  - CMR short axis: 12 min 11 sec ± 5 min 9 sec\textsuperscript{ns}

* p < 0.001
** p < 0.05
End-diastolic volume

$R^2 = 0.607$

Bias 22 ± 27 ml

LOA -32 to 74 ml
End-systolic volume

Bias $7 \pm 16$ ml

$R^2 = 0.697$

LOA -25 to 39 ml
Stroke volume

Bias 12 ± 18 ml

LOA -25 to 49 ml

$R^2 = 0.365$

Bias

3DE [ml]

CMR [ml]

<table>
<thead>
<tr>
<th>20</th>
<th>40</th>
<th>60</th>
<th>80</th>
<th>100</th>
<th>120</th>
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<tr>
<td>20</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td>100</td>
<td>120</td>
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</tbody>
</table>

Diff CMR-3DE [ml]

<table>
<thead>
<tr>
<th>25</th>
<th>50</th>
<th>75</th>
<th>100</th>
<th>125</th>
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<td>25</td>
<td>50</td>
<td>75</td>
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<td>125</td>
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</tbody>
</table>
Ejection fraction

Bias 2 ± 8%

LOA -14 to 18 %

$R^2 = 0.356$

**Graphs:**
- Scatter plot showing the relationship between 3DE and CMR with a linear regression line and the equation $R^2$ Linear = 0.356, $R = 0.597$.
- Bland-Altman plot with the bias, 2SD, and -2SD limits of agreement.

**Equation:**
$$Ejection\ fraction = \text{Bias} 2 \pm 8\%$$

**Regression:**
$$R^2 = 0.356$$

**Limits of Agreement:**
LOA -14 to 18 %
Increased bias without manual correction

<table>
<thead>
<tr>
<th></th>
<th>Corrected 3DE Bias</th>
<th>Uncorrected 3DE Bias</th>
<th>p-value</th>
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<tbody>
<tr>
<td>EDV</td>
<td>-15 ± 18 %</td>
<td>-21 ± 17 %</td>
<td>0.003</td>
</tr>
<tr>
<td>ESV</td>
<td>-10 ± 21%</td>
<td>-10 ± 23 %</td>
<td>0.744</td>
</tr>
<tr>
<td>SV</td>
<td>-15 ± 26%</td>
<td>-28 ± 18 %</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>EF</td>
<td>-3 ± 16%</td>
<td>-11 ± 18 %</td>
<td>0.001</td>
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</table>
Conclusions

- 3DE is feasible in a large proportion of unselected adult patients for visualizing the RV.
- 3DE correlated to CMR.
- The accuracy increases with manual correction of the semi-automatic delineation.
Acknowledgements

- Cardiac MR Group, Skåne University Hospital, Lund University, Lund, Sweden
- Department of Cardiology, Karolinska University Hospital, Huddinge, Stockholm, Sweden
- Department of Cardiology, Skåne University Hospital, Malmö and Lund; Lund University, Sweden
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  - Region of Skåne and Lund University
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Contribution

- Study design
- Fund raising
- Including patients
- Echo acquisition
- 3DE and CMR image analyses
- Statistical analyses
- Writing the abstract
Mean volumes and function

<table>
<thead>
<tr>
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<th>CMR</th>
<th>Corrected 3DE</th>
<th>Uncorrected 3DE</th>
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<tbody>
<tr>
<td>Mean ± SD</td>
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<td>Mean ± SD</td>
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<tr>
<td>EDV</td>
<td>149 ± 40 mL</td>
<td>127 ± 42 mL</td>
<td>117 ± 37 mL</td>
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<tr>
<td>ESV</td>
<td>72 ± 26 mL</td>
<td>64 ± 28 mL</td>
<td>64 ± 24 mL</td>
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<tr>
<td>SV</td>
<td>75 ± 21 mL</td>
<td>63 ± 20 mL</td>
<td>53 ± 19 mL</td>
</tr>
<tr>
<td>EF</td>
<td>52 ± 8 %</td>
<td>50 ± 9 %</td>
<td>46 ± 9 %</td>
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a: compared to CMR, p ≤ 0.001
b: compared to corrected 3DE, p ≤ 0.001
3DE image acquisition difficulties
## Squared Pearson coefficient

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<thead>
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<th>Uncorrected 3DE</th>
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<tbody>
<tr>
<td></td>
<td>$R^2$-value</td>
<td>$R^2$-value</td>
</tr>
<tr>
<td>EDV</td>
<td>0.607</td>
<td>0.591</td>
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<tr>
<td>ESV</td>
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<td>0.598</td>
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<tr>
<td>SV</td>
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<td>0.488</td>
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<tr>
<td>EF</td>
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<td>0.238</td>
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