Abstract: 420

Vortex formation in the pre-ejection phase in the left ventricle

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Topic(s):
Echocardiography: Systolic and Diastolic Function

Citation:
Central Norway Regional Health Authority

Background/Introduction:
Vortex formation during left ventricular filling have been described since the 1980’s. We have investigated vortices in the left ventricle (LV) in healthy adults with a new technology based on high frame rate vector flow imaging (VFI) using blood speckle tracking.

Purpose:
In this study we investigated the intraventricular flow pattern during the pre-ejection period.

Material and methods:
We examined 21 healthy volunteers with a GE E95 ultrasound scanner, both in ordinary clinical mode and with an experimental setup. The latter was developed to achieve high frame rates by utilizing plane waves in combination with ECG-gating over multiple (5-6) heart cycles, allowing continuous acquisition of >3500 FPS. Blood speckle tracking followed by model based regularization was used to obtain vector flow velocity measurements.

Results:
During the pre-ejection phase we observed blood flow from the apex to the basis of the LV along the septum. At the base, the flow is deflected. A basal vortex is then created just above the mitral valve, which persists into the isovolumetric contraction (IVC). The lateral part of the vortex is then seen as an apically directed flow during IVC, as shown in the illustration. The vortex is also visible in the first phase of the ejection; the part of the blood in the LV not passing through the aortic valve is deflected and continues to conserve this vortex. These findings correspond to patterns found in colour M-Mode (CMM), showing a column of blood toward the apex in the IVC/early ejection phase. Time from peak R to the first sighting of this IVC vortex, and to the pre-ejection spike in tissue Doppler imaging (TDI), are similar, as reported in table 1.

Conclusion(s):
Our imaging setup allows for a very high temporal resolution (>3500 FPS), and enables VFI using blood speckle tracking, without using a contrast agent. We observed an intraventricular vortex during pre-ejection and into early ejection, with the same direction as the later vortices seen in filling. Initiation of this vortex may be conserved energy from late filling. This vortex is simultaneous with the pre-ejection spike in TDI. We postulate that this IVC vortex contributes to the closing of the anterior mitral leaflet in the IVC. As we also observe this vortex during the early ejection phase, we believe it may conserve rotational energy into early filling.

<table>
<thead>
<tr>
<th>Timing of the IVC vortex and the pre-ejection spike in TDI</th>
<th>Mean</th>
<th>Median</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time between R and the basal vortex during IVS (ms)</td>
<td>16,7</td>
<td>16</td>
<td>15,1</td>
<td>-13</td>
<td>47</td>
</tr>
<tr>
<td>Time between R and the pre-ejection spike TDI (ms)</td>
<td>16,3</td>
<td>21</td>
<td>14,4</td>
<td>-10</td>
<td>36</td>
</tr>
</tbody>
</table>
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Timing of the IVC vortex and the pre-ejection spike in TDI

<table>
<thead>
<tr>
<th>Mean</th>
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<th>Min</th>
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</tr>
</thead>
<tbody>
<tr>
<td>16,7</td>
<td>16</td>
<td>1.5</td>
<td>-13</td>
<td>47</td>
</tr>
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The IVC vortex seen in CMM and with VFI, and the timing of this versus the pre-ejection spike