Coronary flow velocity assessment on left anterior coronary artery as a marker of atherosclerosis: reliability and accuracy of transthoracic echocardiographic study compared to Doppler flow wire

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- Doppler flow wire investigation (DFW) is the tool of reference for detecting the flow-limiting coronary stenoses.

- Transthoracic echocardiographic selective mapping of Doppler velocities (DFVm) on left anterior descending coronary artery (LAD) has been proposed as a tool capable of offering information about the presence of coronary stenosis, but so far its diagnostic value has not been tested.
Background (1)

Coronary Artery Flow Velocity Is Related To Lumen Area and Regional Left Ventricular Mass

H. Vernon Anderson, MD; Michael J. Stokes, MD; Miltiadis Leon, MD; Subhi A. Abu-Halawa, MD, MPH; Yvonne Stuart, RT; Richard L. Kirkeeide, PhD

TABLE 3. Angiographic and Flow Data by Disease Category

<table>
<thead>
<tr>
<th></th>
<th>No Disease or Luminal Irregularities (n=22)</th>
<th>Mild Disease (n=15)</th>
<th>Moderate Disease (n=22)</th>
<th>P</th>
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</thead>
<tbody>
<tr>
<td>Coronary diameter, mm</td>
<td>3.2±0.7</td>
<td>3.1±0.7</td>
<td>2.6±0.6</td>
<td>0.02</td>
</tr>
<tr>
<td>A/m ratio, mm²/100 g</td>
<td>8.7±4.0</td>
<td>8.5±6.2</td>
<td>5.6±3.0</td>
<td>0.04</td>
</tr>
<tr>
<td>APV, cm/s</td>
<td>27±16</td>
<td>33±11</td>
<td>37±20</td>
<td>0.06</td>
</tr>
<tr>
<td>CFR</td>
<td>2.8±0.7</td>
<td>2.1±0.5</td>
<td>2.2±1.3</td>
<td>0.07</td>
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</table>

Conclusions—Resting coronary artery flow velocity is inversely related to the ratio of lumen area to regional left ventricular mass. Higher resting velocities are found when insufficient lumen size exists for the distal myocardial bed, as occurs with diffuse mild or moderate coronary atherosclerosis. (Circulation. 2000;102:48-54.)
Background (2)

Detection, location, and severity assessment of left anterior descending coronary artery stenoses by means of contrast-enhanced transthoracic harmonic echo Doppler

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1Unit of Cardiovascular Diseases, Dept. of Emergency and Organ Transplantation, University of Bari, Policlinico di Bari, Piazza G. Cesare, 70123 Bari, Italy; 2Division of Cardiology, University of Cagliari, Cagliari, Italy; 3Division of Cardiology, University of Padua, Padua, Italy.

Figure 1: Transthoracic Doppler detection of a significant stenosis in the proximal LAD (plane orientation as in Figure 1). Colour flow in LAD is turbulent and turbulent flow is associated with high velocities (A, B, C, and D). Normal flow Doppler consists of low flow, low velocities, and low velocities (E, F, and G).

Figure 6: Left panel: Bar graph showing individual percentage increases in velocity in the LAD segment with and without stenosis (Y axis mean values and standard deviations). Cut-off (solid horizontal line) with its 95% CIs boundaries (dotted lines) is obtained using the least squares isotonic regression. Right panel: The average velocity of the LAD segment in the stenotic area is significantly lower than in the non-stenotic area.

Conclusions

The use of contrast-enhanced transthoracic Doppler echocardiography to evaluate BFV throughout the LAD coronary artery is a feasible and reliable means of detecting, locating, and preliminarily assessing the severity of LAD stenoses as it identifies the effect of a stenosis on blood flow dynamics. Further studies are needed to verify the usefulness of the method in specific clinical settings.
Ultrasound findings of coronary arteries: Prox-Mid LAD

Feasibility 78% pts

Normal values
MFV=35±9 cm/s

Rigo, Cardiovascular Ultrasound 2008
Ultrasound findings of coronary arteries: Mid-Distal LAD

Lad: mid-distal tract
Feasibility 98% pts

Normal values
MFV=25±7 cm/s
Aim of the Study

To compare the reliability and the relative diagnostic value of DFVm rest velocities in the 3 main segments of LAD coronary artery (Proximal=I, Middle= II, Distal= III) with coronary angiography (CA), CFR and FFR assessed invasively.
Study population

In 2009 we enrolled 17 chest pain patients (mean age 68±9 years) from 3 centers: Mestre-Venice (Italy), Padua (Italy) and Belgrade (Serbia).

Each patient underwent:

1) ECHOCARDIOGRAPHY (Transthoracic – without adding contrast agent- we adopted a dedicated vascular software)

- TTE-Doppler mapping of LAD (a higher flow velocity > 70 cm/s in mid-distal LAD was considered due to coronary stenosis)

- Stress Echo: Dipyridamole (0.84 mg/kg/over 6’)
  Coronary flow reserve on LAD (CFR= Hyperemic DFV/baseline DFV → abnormal CFR value <2)

2) CORONARY ANGIOGRAPHY

- Coronary angiography with Doppler flow wire analysis (ComboWire pressure/Flow wire, Volcano)
## Patient characteristics

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<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td>68.0 ± 11.2</td>
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<tr>
<td><strong>Men/Women (%)</strong></td>
<td>73% / 27%</td>
</tr>
<tr>
<td><strong>FE (%) Left ventricle</strong></td>
<td>52% ± 6</td>
</tr>
<tr>
<td><strong>Familiarity</strong></td>
<td>15.2%</td>
</tr>
<tr>
<td><strong>Diabetes</strong></td>
<td>27%</td>
</tr>
<tr>
<td><strong>Hypertension</strong></td>
<td>55%</td>
</tr>
<tr>
<td><strong>Hypercholesterolemia</strong></td>
<td>58%</td>
</tr>
<tr>
<td><strong>Smoke</strong></td>
<td>36%</td>
</tr>
<tr>
<td><strong>CFR (mean value)</strong></td>
<td>1.7 ± 0.4</td>
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Results (1)

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<tbody>
<tr>
<td><strong>Age</strong></td>
<td>68 ± 9</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>♂ 70%</td>
</tr>
<tr>
<td></td>
<td>♀ 30%</td>
</tr>
<tr>
<td><strong>LAD sten ≥ 50%</strong></td>
<td>59%</td>
</tr>
<tr>
<td><strong>LAD sten ≥ 70%</strong></td>
<td>25%</td>
</tr>
<tr>
<td><strong>CFR-TTE</strong></td>
<td>2.0 ± 0.6</td>
</tr>
<tr>
<td><strong>CFR-DFW</strong></td>
<td>2.1 ± 0.7</td>
</tr>
</tbody>
</table>

- **CFR-TTE** vs. **CFR by Doppler Flow Wire**
  - $r = 0.98; p < 0.001$

- **CFR by TTE** vs. **CFR by Doppler Flow Wire**
  - $r = 0.98; p < 0.001$

- **CFR by TTE - CFR by DFW**
  - Mean: 0.24
  - 1.96 SD: ±0.44
  - -1.96 SD: ±0.10

- **CFR by Doppler Flow Wire** vs. **AVERAGE of CFR by TTE and CFR by DFW**
  - $r = 0.98; p < 0.001$
Results (2)

Proximal LAD (cm/s)
Vel-TTE: 59 ± 24
Vel-DFW: 69 ± 36

Middle LAD (cm/s)
Vel-TTE: 75 ± 44
Vel-DFW: 83 ± 36

Distal LAD (cm/s)
Vel-TTE: 67 ± 26
Vel-DFW: 73 ± 33
Clinical case: coronary stenosis
TTE Doppler mapping of LAD

Proximal LAD: 43 cm/s
Mid LAD: 96 cm/s
Distal LAD: 33 cm/s
Clinical case: DFW mapping of LAD

Proximal LAD
DFW Flow Velocity = 45 cm/s

Mid LAD
DFW Flow velocity = 99 cm/s

Distal LAD
DFW = 35 cm/s
Conclusions

- Transthoracic echocardiographyc selective mapping of doppler velocities of LAD showed good values in terms of reliability and diagnostic accuracy as well as a good overlap with those values obtained by DFW.

- Therefore, the finding of a higher flow velocity or a significant difference between proximal to distal rest velocity on LAD with TTE-Doppler examination, can be considered a marker of LAD coronary narrowing and may become an option for a simple non-invasive screening of patients suspected of having CAD, before performing CFR or any invasive procedure.