Abstract: **3041**

Wall shear stress measurement by ultrafast vector flow imaging for atherosclerotic carotid stenosis

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Topic(s): Carotid Disease

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Background: Carotid plaque vulnerability assessment is an important factor in guiding the decision to treat significant carotid stenosis. Ultrafast Ultrasound Imaging (UF) offers the possibility of evaluating local flow velocities over an entire 2D image, allowing access to velocity measurements in contact with the arterial wall and to measure the wall shear stress (WSS).

Purpose: To evaluate the feasibility of WSS measurement in a prospective series of patients with carotid stenosis.

Methods: A 7.5 MHz linear probe of an Aixplorer scanner was used. UF acquisitions had 3 tilted plane waves transmits (-10; 0; 10°) and an effective frame rate of 5000Hz. We evaluated the flow velocity in 5 areas of the carotid wall: common carotid artery (1), plaque ascent (2), plaque peak (3), plaque descent (4), internal carotid artery (5) (Figure). WSS was computed with the vector field speed using the following formula, WSS=μ.dn.v with v the blood velocity, n the normal vector to the vessel wall and μ, the blood viscosity, calculated from the hematocrit value for each patient. WSS measurement method was first validated using a laminar flow phantom and known viscosity. And then, 33 patients were then prospectively evaluated, with a median carotid stenosis degree of 80% [75–85].

Results: Significant correlation was found between in vitro measurement and the theoretical WSS values (R²=0.95; p<0.001). In patients, the maximum WSS value over the cardiac cycle follows the shape of the plaque with an increase during the ascend, reaching its maximum value of 3.57 Pa [2.47–4.45] at the peak of the plaque, and a fall after passing the peak (0.99 Pa [0.8–1.32]) lower than the WSS values in the non-stenotic areas (1.55 Pa [1.13–1.90] for the common carotid artery) (Table).

Conclusion: UF provide reliable WSS values. High WSS was present at the peak of the plaque, whereas lowest WSS values were found at the post-stenotic zone. WSS evaluation may help to better characterize the carotid plaque vulnerability.

<table>
<thead>
<tr>
<th>Wall’s area</th>
<th>Wall shear stress (Pa)</th>
<th>Min</th>
<th>Max</th>
<th>Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Common carotid artery</td>
<td></td>
<td>0.14 [0.05-0.27]</td>
<td>1.55 [1.13-1.90]</td>
<td>0.73 [0.55-0.96]</td>
</tr>
<tr>
<td>2. Plaque’s ascent</td>
<td></td>
<td>0.39 [0.24-0.59]</td>
<td>2.63 [1.89-3.28]</td>
<td>1.20 [0.89-1.79]</td>
</tr>
<tr>
<td>3. Plaque’s peak</td>
<td></td>
<td>0.60 [0.32-0.89]</td>
<td>3.57 [2.47-4.45]</td>
<td>1.78 [1.44-2.46]</td>
</tr>
<tr>
<td>4. Plaque’s descent</td>
<td></td>
<td>0.16 [0.13-0.22]</td>
<td>0.99 [0.80-1.32]</td>
<td>0.52 [0.34-0.73]</td>
</tr>
<tr>
<td>5. Internal carotid artery</td>
<td></td>
<td>0.17 [0.13-0.35]</td>
<td>1.37 [1.04-1.75]</td>
<td>0.72 [0.50-0.87]</td>
</tr>
</tbody>
</table>

Results are median [25th – 75th percentile]
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