Assessment of Mechanical Properties of Common Carotid Artery in Takayasu’s Arteritis Using Velocity Vector Imaging

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Background (I)

- Alteration of arterial elastic properties is known to occur in patients with arteritis.
- Widespread thickening of the walls of elastic arteries is one of the characteristics of TA.

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- However, mechanical properties of the involved arteries are not well known.
Recently, velocity vector imaging (VVI), a novel method based on speckle tracking, has been suggested to be useful to assess multidimensional regional mechanics such as velocity, strain, strain rate and displacement. Thereby it enables rapid and accurate quantitative measurement of myocardial velocities, strain, and strain rate.

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Purpose

- To investigate the mechanical properties of the common carotid artery using VVI in TA.
Methods

- 12 patients with Takayasu’s arteritis
- 12 age-, gender-matched healthy controls

- Carotid IMT
- Carotid strain
- Carotid VVI
Carotid IMT

- Semi-automatically measured with the Syngo Arterial Health Package (Siemens Medical Solutions USA, Inc., CA, USA)
- All the frames within a single region of interest (1 cm length) selected by the user 1 cm distal to the bulbs
Carotid Strain

- Carotid luminal strain, the percent systolic expansion of the arterial lumen, was calculated as; luminal strain = ([internal diameter at peak systole – internal diameter at peak diastole]/internal diameter at peak diastole) × 100
Carotid VVI

- **Syngo Velocity Vector Imaging technology**
  (Siemens Medical Solution USA, Inc.)

- Transverse plane of a common carotid artery about 1.5 cm from the bifurcation to the aortic arch
Regional Mechanics by VVI

- The software divides arterial wall into 6 segments automatically
Parameters Assessed by VVI

- $P_v$ : peak radial velocity
- $P_s$ : peak circ. strain
- $P_{sr}$ : peak circ. strain rate
- $P_d$ : peak radial displacement
- $T_v$ : time to $P_v$
- $T_s$ : time to $P_s$
- $T_{sr}$ : time to $P_{sr}$
- $T_v$ : time to $P_d$
Dyssynchronous Motion

- Tv-SD : standard deviation of Tv
- Ts-SD : standard deviation of Ts
- Ts-SDr : standard deviation of Tsr
- Td-SD : standard deviation of Td
## Clinical Characteristics

<table>
<thead>
<tr>
<th></th>
<th>TA (n=12)</th>
<th>Controls (n=12)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>38±10</td>
<td>38±10</td>
<td>0.977</td>
</tr>
<tr>
<td>Female (%)</td>
<td>11(91.7)</td>
<td>11(91.7)</td>
<td>0.999</td>
</tr>
<tr>
<td>SBP (mm Hg)</td>
<td>120±17</td>
<td>118±11</td>
<td>0.315</td>
</tr>
<tr>
<td>DBP (mm Hg)</td>
<td>73±9</td>
<td>74±8</td>
<td>0.606</td>
</tr>
<tr>
<td>HR (/min)</td>
<td>73±8</td>
<td>71±9</td>
<td>0.898</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>22.0±2.7</td>
<td>20.7±1.7</td>
<td>0.590</td>
</tr>
</tbody>
</table>
## Carotid IMT, Diameter & Strain

<table>
<thead>
<tr>
<th></th>
<th>TA</th>
<th>Controls</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of examined carotid arteries</td>
<td>23</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>IMT (mm)</td>
<td>1.16±0.48</td>
<td>0.46±0.07</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Internal diameter (mm)</td>
<td>4.24±2.07</td>
<td>5.93±0.64</td>
<td>0.001</td>
</tr>
<tr>
<td>External diameter (mm)</td>
<td>6.41±1.55</td>
<td>6.70±0.72</td>
<td>0.415</td>
</tr>
<tr>
<td>Luminal stenosis (%)</td>
<td>37±22</td>
<td>12±2</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Luminal strain (%)</td>
<td>4.16±4.15</td>
<td>8.66±3.34</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Parameter</td>
<td>TA</td>
<td>Controls</td>
<td>P value</td>
</tr>
<tr>
<td>-----------------</td>
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</tr>
<tr>
<td>( \text{PV} ) (mm/s)</td>
<td>1.17±1.36</td>
<td>1.42±0.59</td>
<td>0.032</td>
</tr>
<tr>
<td>( \text{Ps} ) (%)</td>
<td>3.58±2.99</td>
<td>4.99±2.05</td>
<td>0.015</td>
</tr>
<tr>
<td>( \text{Psr} ) (/s)</td>
<td>0.23±0.18</td>
<td>0.39±0.18</td>
<td>0.004</td>
</tr>
<tr>
<td>( \text{Pd} ) (mm)</td>
<td>0.15±0.06</td>
<td>0.31±0.20</td>
<td>0.007</td>
</tr>
<tr>
<td>( \text{Tv-SD} ) (msec)</td>
<td>38.2±26.4</td>
<td>13.3±10.0</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>( \text{Ts-SD} ) (msec)</td>
<td>199.3±93.7</td>
<td>87.1±58.4</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>( \text{Tsr-SD} ) (msec)</td>
<td>74.9±34.8</td>
<td>28.7±19.4</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>( \text{Td-SD} ) (msec)</td>
<td>125.4±93.1</td>
<td>41.9±36.4</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>
Standard Deviation of Tsr

$P < 0.0001$

Takayasu’s arteritis

Controls
Dyssynchronous Motion & Stenosis

- Luminal stenosis of carotid arteries (%)

- $r = 0.471$
  $p = 0.023$

- $r = 0.558$
  $p = 0.006$

- $Tv-SD$ (msec)
- $Ts-SD$ (msec)
Dyssynchronous Motion & Stenosis

- Luminal stenosis of carotid arteries (%)
- Tsr-SD (msec)
- Td-SD (msec)

$r = 0.503\quad p = 0.015$

$r = 0.615\quad p = 0.002$
Summary

- Velocity, strain, strain rate and displacement were decreased significantly in TA.
- SDs of Tv, Ts, Tsr and Td of multiple arterial wall segments were higher in TA, suggesting disturbance of symmetric arterial expansion during systole.
- The severity of carotid stenosis was positively correlated with SDs of Tv, Ts, Tsr and Td.
Limitations

- Small number of the patient population, reflecting the rarity of TA
- Two-dimensional speckle tracking algorithms used in VVI are dependent on image quality and intima-media complex border definition
- Application of VVI for arterial wall has not been validated
Conclusion

- In patients with TA, carotid artery showed dyssynchronous arterial expansion during systole when compared with healthy controls.
- Arterial assessment using VVI may represent a new noninvasive method for quantifying vascular alteration associated with arteritis.
Thank you for your attention.