Comparison of automatic border detection software with manual electronic calipers in the quantification of arterial layer thickness with very-high resolution ultrasound

**BACKGROUND**

Non-invasive very-high resolution vascular ultrasound (VHRU, 25-55 MHz) has recently been developed but images are currently analyzed with manual electronic calipers (EC). The aim was to compare the use of semi-automatic border detection software (AMS; Artery Measurement System) with EC in the analysis of arterial images obtained with transcutaneous VHRU.

**METHODS**

100 images from central elastic (common carotid) and peripheral muscular (brachial, radial, femoral, tibial) arteries were obtained on two separate occasions from 10 healthy subjects of different sizes and ages including both adults and children. AMS and EC were independently used to measure lumen dimension (LD) and intima-media thickness (IMT) for all arteries and intima-media-adventitia thickness (IMAT) for muscular arteries. Adventitia thickness (AT) was calculated as the difference between IMT and IMAT. The intra-, inter-, and test-retest variability for each measurement were assessed for both systems.

**RESULTS**

No bias between AMS and EC was found. Significant differences in intraobserver CVs between AMS and EC were observed for carotid LD (AMS 0.4 vs. EC 1.9 %, p = 0.033) and a trend was also seen in interobserver LD (AMS 1.4 vs. EC 2.6 %, p = 0.098), test-retest femoral LD (AMS 8.9 vs. EC 7.3 %, p = 0.020) and AT (AMS 23.4 vs. EC 37.4 % p = 0.050). No consistently significant differences in intra, inter or test-retest CVs were, however, observed for muscular artery LD, IMT, IMAT or AT between AMS and EC. The intraobserver CV for AT (AMS 15.6 vs. EC 12.1 %, p = 0.001; mean 0.219 mm; N=58) obtained with AMS in higher quality muscular artery images was lower compared with EC. When comparing images of lower quality the CV was significantly smaller for AMS when measuring intraobserver LD (AMS 1.9 vs. EC 4.3, p = 0.032) and trend was seen in interobserver LD (AMS 4.7 vs. EC 6.9, p = 0.054).

**CONCLUSION**

Minor, although statistically significant, differences in the precision of AMS and EC-systems may be found in the analysis of arterial images obtained with VHRU. The technical variance of the measurement seems to be more related to vessel size, measurement dimension, image quality and type of agreement.

**Table 1**: Intraobserver agreement of AMS and EC for different transducer frequencies, arterial sites and dimensions. LD, lumen dimension; IMT, intima-media thickness; IMAT, intima-media-adventitia thickness; AT, adventitia thickness; CV, coefficient of variation; ∆Mean, mean difference; LOA 95%, 95% limits of agreement; AMS, semi-automatic border detection; EC, electronic calibre. The p-value is calculated as a comparison of the absolute differences for the two methods.

<table>
<thead>
<tr>
<th>Artery</th>
<th>N</th>
<th>AMS</th>
<th>EC</th>
<th>AMS</th>
<th>EC</th>
<th>CV %</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carotid 25 MHz</td>
<td>20</td>
<td>5.601</td>
<td>5.559</td>
<td>0.010</td>
<td>-0.036, 0.056</td>
<td>0.034</td>
<td>(-0.177, 0.240)</td>
</tr>
<tr>
<td>Femoral 25 MHz</td>
<td>20</td>
<td>0.373</td>
<td>0.358</td>
<td>-0.006</td>
<td>-0.072, 0.061</td>
<td>-0.001</td>
<td>(-0.069, 0.067)</td>
</tr>
<tr>
<td>Brachial, Radial, Tibial 35-55 MHz</td>
<td>60</td>
<td>0.108</td>
<td>0.106</td>
<td>-0.001</td>
<td>-0.047, 0.045</td>
<td>0.000</td>
<td>(-0.051, 0.051)</td>
</tr>
</tbody>
</table>

**Table 2**: Intraobserver agreement of AMS and EC for images of different qualities.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Quality 1-2</th>
<th>N</th>
<th>AMS</th>
<th>EC</th>
<th>AMS</th>
<th>EC</th>
<th>CV %</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LD</td>
<td>1-2</td>
<td>41</td>
<td>4.820</td>
<td>4.823</td>
<td>-0.023</td>
<td>-0.205, 0.159</td>
<td>-0.027</td>
<td>-0.434, 0.380</td>
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<tr>
<td>IMT</td>
<td>1-2</td>
<td>35</td>
<td>3.704</td>
<td>3.696</td>
<td>-0.001</td>
<td>-0.087, 0.085</td>
<td>0.008</td>
<td>(-0.108, 0.125)</td>
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<tr>
<td>IMAT</td>
<td>1-2</td>
<td>36</td>
<td>0.218</td>
<td>0.214</td>
<td>0.004</td>
<td>-0.033, 0.041</td>
<td>0.000</td>
<td>(-0.038, 0.038)</td>
</tr>
<tr>
<td>AT</td>
<td>1-2</td>
<td>38</td>
<td>0.451</td>
<td>0.464</td>
<td>0.016</td>
<td>-0.072, 0.104</td>
<td>-0.008</td>
<td>-0.110, 0.094</td>
</tr>
<tr>
<td>LD</td>
<td>1-2</td>
<td>41</td>
<td>0.273</td>
<td>0.269</td>
<td>0.003</td>
<td>-0.035, 0.041</td>
<td>0.004</td>
<td>-0.048, 0.057</td>
</tr>
<tr>
<td>IMT</td>
<td>1-2</td>
<td>38</td>
<td>0.172</td>
<td>0.186</td>
<td>0.007</td>
<td>-0.071, 0.086</td>
<td>-0.013</td>
<td>-0.114, 0.088</td>
</tr>
<tr>
<td>AT</td>
<td>1-2</td>
<td>38</td>
<td>0.111</td>
<td>0.109</td>
<td>-0.004</td>
<td>-0.038, 0.030</td>
<td>0.003</td>
<td>-0.050, 0.056</td>
</tr>
</tbody>
</table>

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