Multilevel Assessment of Atherosclerotic Extent Using a 40-Section Multidetector Scanner after Transient Ischemic Attack or Ischemic Stroke


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**ABSTRACT**

**BACKGROUND AND PURPOSE:** The first part of this study assessed the potential of MDCT with a CTA examination of the aorta and the coronary, cervical, and intracranial vessels in the etiologic work-up of TIA or ischemic stroke compared with established imaging methods. The objective of the second part of this study was to assess the atherosclerotic extent by use of MDCT in these patients.

**MATERIALS AND METHODS:** From August 2007 to August 2011, a total of 96 patients with ischemic stroke or TIA without an evident cardioembolic source were enrolled. All patients underwent MDCT. Atherosclerotic extent was classified in 0, 1, 2, 3, and 4 atherosclerotic levels according to the number of arterial territories (aortic arch, coronary, cervical, intracranial) affected by atherosclerosis defined as ≥50% cervical, intracranial, or coronary stenosis or ≥4-mm aortic arch plaque.

**RESULTS:** There were 91 patients who had an interpretable MDCT. Mean age was 67.4 years (±11 years), and 75 patients (83.3%) were men. The prevalence of 0, 1, 2, 3, and 4 atherosclerotic levels was 48.3%, 35.2%, 12.1%, 4.4%, and 0%, respectively. Aortic arch atheroma was found in 47.6% of patients with 1 atherosclerotic level. The combination of aortic arch atheroma and cervical stenosis was found in 63.6% of patients with ≥2 atherosclerotic levels. Patients with ≥2 atherosclerotic levels were older than patients with <2 atherosclerotic levels (P = .04) in univariate analysis.

**CONCLUSIONS:** MDCT might be useful to assess the extent of atherosclerosis. It could help to screen for high-risk patients who could benefit from a more aggressive preventive strategy.

**ABBREVIATION:** ECG = electrocardiogram
consent from each patient. It has been demonstrated that MDCT is feasible and accurate for the identification of stroke causes though its sensitivity for the detection of minor cardiac sources is limited.

The objective of the second part of our study was to assess the global atherosclerotic extent by using MDCT in these patients.

**MATERIALS AND METHODS**

**Research Design**

In the second part of our study, we used data collected in the first part of the study.6

**Imaging Protocols**

We performed contrast-enhanced MDCT by using a Brilliance 40 scanner (Philips Healthcare, Best, the Netherlands), with iomeprol (Iomeron 400; Bracco Diagnostics, Milan, Italy) injected into the right cubital vein with an 18-gauge catheter. The patient was placed in the supine, head-first position. A 2-step protocol was performed: first, electrocardiogram (ECG)-gated aortic and heart acquisitions were performed in the head-to-feet direction, encompassing the aortic and heart area from the top of the aortic arch to the diaphragm. The following parameters were used: 40 detectors, individual detector width of 0.625 mm, retrospective ECG gating, tube voltage of 120 kV, tube current of 300 mAs, pitch of 0.2, and half-rotation reconstruction. Iomeprol 70 mL and then saline solution 60 mL were injected at 4 mL/s. A bolus-tracking method was used with an attenuation threshold of 200 Hounsfield units in the ascending aorta. Reconstruction parameters for the axial sections were a 1.5-mm effective section thickness, 1-mm increments, a reconstruction filter Cardiac B, and an adapted field of view. Retrospective ECG-gated reconstruction was performed at 40% and 75% of the R-R interval. Then, 2 minutes later, a non-ECG-gated acquisition from the aortic arch to the vertex (approximately 50 cm) was performed with the following parameters: feet-to-head direction, section thickness of 1.2 mm, pitch of 1.2, tube voltage of 120 kV, amperage of 300 mAs per section, reconstruction filter B, and the bolus tracker set on the aortic arch with an attenuation threshold at 200 Hounsfield units. Iomeprol 50 mL and then saline solution 60 mL were injected at 4 mL/s, for a total injected contrast material volume of 120 mL. The patient underwent imaging with the arms over the head during the aortic and heart acquisitions and with the arms at the sides during the second acquisition. General guidelines for ECG-gated cardiac MDCT were followed regarding the qualifications of the personnel, radiation dose monitoring, and the safety rules for contrast agent and 

**Statistical Analysis**

Continuous variables were expressed as mean (standard deviation), and categoric variables were expressed as percentages. We compared continuous variables by using the t test or the Mann-Whitney test where appropriate, and categoric variables by using the Pearson χ² test or the Fisher exact test where appropriate. The associations between atherosclerotic extent (<2 vs ≥2 atherosclerotic levels) and main vascular risk factors were measured by calculation of adjusted odds ratios and 95% confidence intervals by logistic regression analyses.

Multivariable models were adjusted for age, sex, diabetes, hypertension, dyslipidemia, and tobacco. The distribution of arterial disease combinations in patients with ≥2 atherosclerotic levels was compared by use of the Fisher exact test. A P value <.05 was considered statistically significant.

We performed statistical analysis by using STATA, version 11.0 (StataCorp, College Station, Texas) and R software, version 2.10.1 (http://www.r-project.org/).

**RESULTS**

Ninety-six patients were included. MDCT with CTA examination of the heart, aorta, and the cervical and intracranial vessels was not
done or was not interpretable in 5 patients. The characteristics of the remaining 91 patients are shown in Table 1. Mean age was 67.4 (± 11.0) years, 75 patients (83.3%) were men, 38 (41.1%) were diagnosed with ischemic stroke, and 53 (58.9%) were diagnosed with a TIA. The mean radiation dose to the patients was 18.7 (± 5.0) mSv.

The prevalence of ≥4 mm aortic arch atheroma, ≥50% coronary artery stenosis, ≥50% cervical artery stenosis, and ≥50% intracranial artery stenosis was 23.3%, 14.1%, 23.9%, and 13.6%, respectively (Fig 1).

Forty-four patients (48.3%) had no atherosclerotic level. The prevalence of 1, 2, 3, and 4 atherosclerotic levels was 35.2%, 12.1%, 4.4%, and 0%, respectively. Demographic and clinical data according to the number of atherosclerotic levels are detailed in Table 2. Results did not differ according to diagnosis (TIA vs ischemic stroke) (P = .75). The number of atherosclerotic levels was not associated with classic vascular risk factors besides age. Patients with ≥2 atherosclerotic levels were older than patients with < 2 atherosclerotic levels (P = .04). After adjustment for main confounding variables, this association was not found.

Among patients with 1 atherosclerotic level, 47.6% had ≥4 mm aortic arch atheroma, 20.7% had ≥50% coronary artery stenosis, 26.7% had ≥50% cervical artery stenosis, and 26.7% had ≥50% intracranial artery stenosis. Among patients with 2 atherosclerotic levels, 63.6% had both ≥4 mm aortic arch atheroma and ≥50% cervical artery stenosis. Among patients with 3 atherosclerotic levels, 50% had both ≥4 mm aortic arch atheroma and ≥50% cervical and coronary artery stenosis. The distribution of artery disease combinations in patients with ≥2 atherosclerotic levels was significantly different (P = .022) (Fig 2). Aortic arch atheroma ≥4 mm and ≥50% cervical artery stenosis were most often associated.

**DISCUSSION**

We have shown that 16.5% of patients with stroke or TIA without evident cardioembolic source have ≥2 atherosclerotic levels by use of MDCT. The combination of ≥4 mm aortic arch atheroma and ≥50% cervical and coronary artery stenosis was more often found.

The extent of atherosclerosis is heavier than in a previous study assessing 3 arterial levels (aorta, coronary, and cervical arteries) by use of a CTA protocol in patients with suspicion for TIA or stroke. In this previous study, among 79 patients, 26 (33%) had 1 atherosclerotic level, mainly ≥50% coronary artery stenosis. Only 7 patients (9%) had at least 2 atherosclerotic locations. The enrollment of patients with suspicion of TIA or stroke confirmed in only 60% of cases and the lack of assess-

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**Table 1: Demographic and medical data according to number of atherosclerotic levels in 91 patients**

<table>
<thead>
<tr>
<th>Number of atherosclerotic levels</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients, n (%)</td>
<td>44</td>
<td>32</td>
<td>11</td>
<td>4</td>
<td>91</td>
</tr>
<tr>
<td>Age, y, mean (SD)</td>
<td>63.6 (10.6)</td>
<td>70.1 (10.3)</td>
<td>72.5 (10.8)</td>
<td>72.5 (10.0)</td>
<td>67.4 (11.0)</td>
</tr>
<tr>
<td>Male sex, n (%)</td>
<td>36</td>
<td>25</td>
<td>10</td>
<td>4</td>
<td>75</td>
</tr>
<tr>
<td>TIA, n (%)</td>
<td>27</td>
<td>17</td>
<td>6</td>
<td>3</td>
<td>53</td>
</tr>
<tr>
<td>Stroke</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial NIHSS, mean (SD)</td>
<td>5.2 (3.9)</td>
<td>7.7 (5.4)</td>
<td>6.5 (5.8)</td>
<td>0.3 (0.6)</td>
<td>6.1 (4.9)</td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>15</td>
<td>16</td>
<td>5</td>
<td>2</td>
<td>38</td>
</tr>
<tr>
<td>LDL cholesterol, g/L</td>
<td>1.23 (0.3)</td>
<td>1.20 (0.4)</td>
<td>1.14 (0.3)</td>
<td>1.50 (0.4)</td>
<td>1.22 (0.4)</td>
</tr>
<tr>
<td>Smoking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Former</td>
<td>7</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>19</td>
</tr>
<tr>
<td>Current</td>
<td>11</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>21</td>
</tr>
<tr>
<td>Never</td>
<td>25</td>
<td>17</td>
<td>6</td>
<td>1</td>
<td>49</td>
</tr>
<tr>
<td>CRP, mg/L (%)</td>
<td>10.0 (27.0)</td>
<td>6.1 (7.5)</td>
<td>4.5 (4.3)</td>
<td>3.0 (1.6)</td>
<td>7.7 (19.6)</td>
</tr>
<tr>
<td>Fibrinogen, g/L (%)</td>
<td>3.4 (1.0)</td>
<td>3.6 (0.8)</td>
<td>3.2 (1.1)</td>
<td>3.6 (0.3)</td>
<td>3.5 (1.0)</td>
</tr>
<tr>
<td>History of vascular disease (%)</td>
<td>9</td>
<td>11</td>
<td>6</td>
<td>0</td>
<td>26</td>
</tr>
</tbody>
</table>

Note: —CRP indicates C-reactive protein; LDL, low-density lipoprotein; SD, standard deviation.

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**FIG 1.** MDCT images (40 sections) show atherosclerosis of the aortic arch (A), internal carotid artery (B), left middle cerebral artery (C), and circumflex coronary artery (D).
The association between aortic and cervical atherosclerosis was not found by MDCT in this previous study (Adraktas et al).\textsuperscript{13} but has been commonplace in studies using transesophageal echocardiography and carotid ultrasonography in patients with stroke.\textsuperscript{14-16} A prospective study and a case-control study have shown that aortic plaques were more likely detected in patients with stroke with 50% carotid artery stenosis compared with <50% carotid artery stenosis.\textsuperscript{14,15} Similar results have been shown with mobile thrombi. This association was also found in a third study.\textsuperscript{16}

The distribution of atherosclerotic disease is in line with previous studies using MDCT in patients with stroke apart from cervical stenosis. Studies have detected ≥50% intracranial artery stenosis in 10% of cases\textsuperscript{17} and ≥4-mm aortic arch plaques in approximately 20% of cases,\textsuperscript{4,18} which could have contributed to stroke occurrence. Asymptomatic coronary artery disease has also been detected in 18%–37.5% of cases.\textsuperscript{18-22} The prevalence of at least 1 ≥50% cervical artery stenosis assessed by MDCT in patients with stroke is not available.

The main limitation of our CT protocol was the required radiation dose. Despite an attempt to lower the dose by decreasing the milliampere-second setting (from 300 mAs per section), the retrospective helical mode we used for cardiac examination led to high radiation exposure.

A MDCT protocol allows assessment of not only the aortic, cervical, and intracranial arteries as a usual etiologic work-up of TIA and stroke but also of the coronary arteries. The rate of cardiac mortality is twice as high as cerebrovascular mortality in patients with stroke.\textsuperscript{23,24} Detection of asymptomatic coronary artery stenosis could lead to optimized preventive strategies. Indeed, some anatomic patterns of coronary artery disease such as significant left main stenosis or multivessel disease are strong indications for revascularization.\textsuperscript{25}

**REFERENCES**


