Detection of Intracranial Atherosclerosis
Which Imaging Techniques Are Available in European Hospitals?

Clotilde Balucani, MD; Didier Leys, MD, PhD; E. Bernd Ringelstein, MD, PhD; Markku Kaste, MD, PhD; Werner Hacke, MD, PhD; for the Executive Committee of the European Stroke Initiative

Background and Purpose—The diagnosis of intracranial atherosclerosis requires availability of appropriate imaging techniques. The objective was to evaluate the proportion of European hospitals where imaging techniques necessary to detect intracranial atherosclerosis are available.

Method—We randomly selected 886 hospitals in 25 countries and classified them in 3 categories according to the availability of 3 imaging techniques (transcranial color-coded duplex imaging, computed tomographic angiography, and magnetic resonance angiography): “all” when the 3 techniques were available, “at least 1,” and “none.” We compared the proportion of hospitals meeting these criteria, using the odds ratio method and Germany as reference.

Results—Two hundred seventy-two hospitals (30.7%) met criteria for all, 445 (50.2%) met criteria for at least 1, and 169 (19.1%) met criteria for none. In 2005, they had admitted, respectively, 139,118, 160,393, and 62,667 stroke patients. Brain CT or MRI were available in 820 (92.6%) hospitals, computed tomographic angiography in 619 (69.9%), magnetic resonance angiography in 498 (56.2%), and transcranial color-coded duplex in 352 (39.7%). Compared to Germany, Greece (OR, 0.11; 95% CI, 0.01–0.88), Iberic countries (OR, 0.11; 95% CI, 0.05–0.27), Baltic countries (OR, 0.13; 95% CI, 0.03–0.56), Poland (OR, 0.40; 95% CI, 0.21–0.77), and France (OR, 0.52; 95% CI, 0.31–0.89), had significantly less hospitals in the all group.

Conclusion—In Europe, less than one-third of ischemic stroke patients are admitted in hospitals with all imaging techniques available to detect intracranial atherosclerosis. There are important differences between countries. (Stroke. 2009;40:726-729.)

Key Words: atherosclerosis ■ stroke care ■ stroke unit ■ survey

Intracranial atherosclerosis is a potential source of cerebral ischemia, occurring more frequently in blacks and Asians than in whites.1–4 Although there is no specific therapy validated to date for intracranial atherosclerosis, this condition may require more aggressive therapeutic strategies5,6 because of a risk of recurrent stroke of 12% after 1 year.3,7 Therefore, intracranial atherosclerosis should be identified in ischemic stroke patients.8 Noninvasive imaging with transcranial color-coded duplex (TCCD) imaging, computed tomographic angiography (CTA), or magnetic resonance angiography (MRA) are effective to detect intracranial atherosclerosis and are relatively risk-free.

Because the level of stroke care is not optimal in many European hospitals, because of lacking facilities,9 we hypothesized that many ischemic stroke patients are admitted in hospitals without the imaging techniques necessary to detect intracranial atherosclerosis. The objective of this study was to evaluate the proportion of European hospitals admitting acute stroke patients in routine when imaging techniques necessary to detect intracranial atherosclerosis were not available.

Materials and Method

General Management of the Survey
This study is an ancillary study of the European hospital facilities survey.9 This survey was conducted in 25 countries, ie, countries that were members of the European Union in 2006 (except Cyprus and Malta), plus Switzerland and Norway. For each country surveyed, a list of hospitals was obtained by an independent company (Datamonitor, UK), as previously reported.9 To be eligible, hospitals had to have admitted at least 1 acute stroke patient in 2005. Hospitals that were not supposed to admit acute strokes (maternities, psychiatric hospitals, nursing homes, rehabilitation centers) were excluded. The respondent, a senior physician with responsibility for acute stroke care, received a 9-page questionnaire, with a letter from the chairman of the Executive Committee of the European Stroke Initiative, explaining the purpose. Questionnaires were mailed in January 2006.

The number of hospitals recruited per country was predefined and based on the country population: 1.5 to 2 hospitals were surveyed per 1 million inhabitants, with a minimum of 2 per country. Hospitals were contacted by Datamonitor, and the writing committee was blinded to the final list of participating hospitals to prevent any potential bias in the interpretation of the results, and for confidentiality.

The questionnaire was based on a previously published expert survey.10 The results of the hospital survey are detailed in the main
They can be summarized as follows: of 4261 hospitals contacted, 1688 admitted at least 1 acute stroke patient in 2005, of which 886 (52.5%) returned the questionnaire; they admitted 331,490 acute stroke patients in 2005 (median, 300 per hospital); 826 (93.2%) had treated stroke patients in 2005.

Specific Methodology

We considered imaging techniques as available when they were present in the hospital, irrespective of their use in routine for stroke patients. When a facility was not available, we did not take into account whether the patients could be referred to another more equipped hospital. For the purpose of this study, we classified hospitals in 3 categories.

Category 1 is “all imaging techniques available.” We classified hospitals in this category when all 3 minimally invasive procedures to detect intracranial atherosclerosis (TCCD, CTA, and MRA) were available. These imaging techniques are those recommended to detect intracranial atherosclerosis by the European Stroke Organisation.8 The availability of multimodal imaging allows exploration of patients who have contraindication for 1 of the techniques or failure. We did not consider availability of digital subtraction angiography (DSA) as an appropriate screening test, because its use is associated with a 1% to 3% risk of stroke in symptomatic patients.11–13 The combination of TCCD and MRA provides excellent results, similar to those of DSA,14 and CTA alone has a better positive predictive value for intracranial atherosclerosis than DSA.15

Category 2 is “at least 1 imaging technique available.” We classified hospitals in this category when at least 1 of the 3 minimally invasive procedures to detect intracranial atherosclerosis (TCCD, CTA, and MRA) was available. The availability of only at least 1 imaging technique makes that the exploration of patients who have contraindication for MRA, or allergy to contrast, or lack of temporal window for TCCD more difficult, with a risk of missing the diagnosis in the absence of another technique.

Category 3 is “no imaging technique available.” We classified hospitals in this category when none of the 3 minimally invasive procedures to detect intracranial atherosclerosis (TCCD, CTA, and MRA) were available, and when neither CT nor MRI were available. These hospitals have no chance to detect intracranial atherosclerosis or to prove cerebral ischemia.

Statistical Analysis

The statistical analysis consisted in determining the proportion of hospitals meeting criteria for all imaging techniques available, at least 1 imaging technique available, and no imaging technique available, as defined, and the number of patients who were admitted in each category in 2005. The proportion of hospitals meeting criteria for all imaging techniques available vs the remainders was compared between countries with the OR method using Germany as reference.
The same analysis was performed between hospitals meeting criteria for no imaging technique available and the remainders.

## Results

Of 886 hospitals, 272 (30.7%) met criteria for the category all imaging techniques available, 445 (50.2%) met criteria for at least 1 imaging technique available, and 169 (19.1%) met criteria for no imaging technique available; 5 of the latter (3.0% of this group; 0.6% of all hospitals) had availability of DSA. The number of stroke patients admitted in 2005 could not be determined in 5 hospitals (0.6%) located in France in Italy. Those hospitals were excluded for the calculation of the number of patients treated in the participating hospitals. In 2005, the 881 remaining hospitals had admitted 139 118 strokes supposed to have occurred in these countries in 2005.9

### Table 2. Analysis Per Country or Groups of Countries Compared With Germany

<table>
<thead>
<tr>
<th>GNP Hospitals</th>
<th>All Imaging Techniques</th>
<th>OR 95% CI</th>
<th>All Plus at Least 1 Imaging Techniques</th>
<th>OR 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria/Switzerland</td>
<td>44 23</td>
<td>10</td>
<td>1.40</td>
<td>0.58–3.38</td>
</tr>
<tr>
<td>Benelux</td>
<td>36 31</td>
<td>13</td>
<td>1.31</td>
<td>0.60–2.86</td>
</tr>
<tr>
<td>Central Europe</td>
<td>11 41</td>
<td>10</td>
<td>0.59</td>
<td>0.27–1.28</td>
</tr>
<tr>
<td>Scandinavia</td>
<td>45 38</td>
<td>14</td>
<td>1.06</td>
<td>0.51–2.20</td>
</tr>
<tr>
<td>Baltic countries</td>
<td>8 28</td>
<td>2</td>
<td>0.13</td>
<td>0.03–0.56</td>
</tr>
<tr>
<td>France</td>
<td>36 121</td>
<td>27</td>
<td>0.52</td>
<td>0.31–0.89</td>
</tr>
<tr>
<td>Germany</td>
<td>35 166</td>
<td>59</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Greece</td>
<td>20 17</td>
<td>1</td>
<td>0.11</td>
<td>0.01–0.88</td>
</tr>
<tr>
<td>UK and Ireland</td>
<td>38 125</td>
<td>46</td>
<td>1.06</td>
<td>0.65–1.71</td>
</tr>
<tr>
<td>Italy</td>
<td>30 116</td>
<td>50</td>
<td>1.37</td>
<td>0.85–2.23</td>
</tr>
<tr>
<td>Poland</td>
<td>7 78</td>
<td>14</td>
<td>0.40</td>
<td>0.21–0.77</td>
</tr>
<tr>
<td>Iberic countries</td>
<td>23 102</td>
<td>6</td>
<td>0.11</td>
<td>0.05–0.27</td>
</tr>
</tbody>
</table>

GNP indicates gross national product (in thousands US dollars per inhabitant) in 2005. Benelux includes Belgium, Netherlands, and Luxembourg. Central Europe includes Czech Republic, Slovakia, Slovenia, and Hungary. Scandinavia included Finland, Denmark, Norway and Sweden. Iberic countries includes Spain and Portugal.

Approximately 50% of hospitals had at least 1 imaging techniques. It is likely that in these hospitals the choice of the technique used to detect intracranial atherosclerosis is more influenced by the technique available than by what is the most sensitive technique to detect intracranial atherosclerosis. Moreover, the sensitivity of TCCD, CTA, and MRA is not the same, and sometimes 1 of the 3 techniques cannot be applied for good reasons. At the level of a single patient, 2 techniques are probably enough to make a diagnosis of intracranial atherosclerosis (usually TCCD and MRA or TCCD and CTA). However, because some patients have contraindications for 1 of the techniques (eg, pacemaker for MRA or allergy to contrast for CTA) or have no temporal window for TCCD, at the level of the hospital the 3 techniques should be available to be able to make the diagnosis when 1 technique is contraindicated or fails. Therefore, these hospitals may miss diagnoses of intracranial atherosclerosis.
In the no imaging technique available group, few hospitals have no possibility to perform a minimally invasive approach, but DSA was available. This is surprising because CTA, MRA, and especially TCCD are less invasive and cheaper techniques, with a good level of diagnostic accuracy as compared with DSA.\textsuperscript{14,17}

Hospitals with all imaging techniques available to detect intracranial atherosclerosis admit more stroke patients than hospitals without those imaging techniques; 42% of stroke patients admitted in 2005 in the participating hospitals were admitted in hospitals with all imaging techniques available, and <10% of stroke patients were admitted to those with no imaging technique. These results are not optimal but they are better than what has been found in the same hospitals for the proportion of stroke patients who could be admitted in comprehensive or in primary stroke centers.\textsuperscript{9} Our survey found heterogeneity among techniques available and countries. Of the 3 minimally invasive techniques, CTA was the most frequently available technique, followed by MRA and TCCD. Differences between countries are probably somewhat explained by differences in economic levels. France is classified as a less-equipped country; it has a similar Gross National Product as Germany and Benelux but higher than Italy, yet it is less equipped. No country had a higher level of imaging techniques than Germany, despite a nonsignificant tendency in favor of Scandinavia, Benelux, and Austria/Switzerland.

This survey has shown that of 10 ischemic stroke patients in Europe, 6 are admitted in hospitals without all imaging techniques available to detect intracranial atherosclerosis, and 1 is admitted in hospitals without any imaging techniques available. However, this does not mean that the search for intracranial atherosclerosis was performed properly in practice. The lack of facilities for a diagnosis of intracranial atherosclerosis, and their probable underuse in practice, may contribute to the apparent low frequency of this condition in European ischemic stroke patients.

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