Incidence of First Stroke
A Population Study in Iceland

Agust Hilmarsson, MD; Olafur Kjartansson, MD; Elias Olafsson, MD, PhD

Background and Purpose—Iceland is an island in the North Atlantic with ≈319,000 inhabitants. The study determines the incidence of first stroke in the adult population of Iceland during 12 months, which has not been previously reported in the entire Icelandic population.

Methods—The study population consisted of all residents of Iceland, aged ≥18 years, during the 12-month study period. Cases were identified by multiple overlapping approaches. Medical records were reviewed to verify diagnosis, to determine stroke subtype and to determine selected risk factors.

Results—A total of 343 individuals, aged ≥18 years, had a first stroke during the study period. Incidence was 144 per 100,000 person years; 81% ischemic infarction; 9% intracerebral hemorrhage; 7% subarachnoid hemorrhage; and 3% unknown. Fifty percent of the individuals were men. Mean age for ischemic infarction and intracerebral hemorrhage was 71 years for men and 73 years for women. Atrial fibrillation was previously known in 18% with first ischemic stroke or intracerebral hemorrhage and another 6% were diagnosed on routine admission ECG. Long-term ECG study (24 hours) found that 12% (18/154) of the remaining individuals had paroxysmal atrial fibrillation.

Conclusions—Incidence of first stroke in Iceland is similar to other Western countries. The high number of paroxysmal atrial fibrillation found during the 24-hour ECG suggests that atrial fibrillation may be underdiagnosed in patients with stroke. (Stroke. 2013;44:1714-1716.)

Key Words: atrial fibrillation ■ Iceland ■ incidence ■ population study ■ stroke

Stroke is a major cause of long-term disability and the second leading cause of death worldwide.¹ The incidence of first stroke has been reported from several well-defined populations, including 144 per 100,000 individuals in southern Sweden,² 145 in Rochester, MN,³ and 145 in Oxfordshire, England.⁴ The purpose of this study is to determine the incidence of stroke in the adult population of Iceland, frequency of stroke subtypes, and selected risk factors.

Materials and Methods

Inclusion Criteria
The index cases are registered inhabitants of Iceland, aged ≥18 years, diagnosed with a first stroke during a 12-month period from October 1, 2007, through September 30, 2008. Stroke is defined based on clinical criteria (World Health Organization definition).¹ We excluded (1) recurrent stroke, (2) transient ischemic attack (clinical symptoms, compatible with stroke but lasting <24 hours), even if imaging study demonstrated a lesion, (3) stroke occurring immediately after major surgery (eg, open heart surgery, carotid endarterectomy, etc), and (4) asymptomatic brain infarcts detected on imaging studies.

Study Population
The Icelandic population in mid-2008 was 319,355 individuals, 238,984 who were ≥18 years of age and 5.6% were ≥75 years of age.⁶ There is 1 university hospital (Landspitali University Hospital [LUH]), located in Reykjavik, which has the only specialized neurology department in the country and is the primary hospital for acute stroke in two thirds of the population and a referral hospital for the rest. The healthcare system provides ready, and affordable, access to hospitals for individuals with symptoms of acute stroke.

Case Finding
We monitored regularly stroke admissions to all hospitals in Iceland, and admissions to the LUH were monitored daily. Primary care physicians, nursing home physicians, and staff were contacted at regular intervals. We reviewed records of all radiology departments to identify individuals with first stroke. The great majority of all suspected stroke cases were discovered and reviewed during the initial admission for stroke.

We reviewed medical records of all suspected stroke cases to (1) verify diagnosis, (2) determine if this was the first stroke, (3) determine the stroke type, (4) determine the pathogenic category of stroke according to the Trial of Org 10172 in Acute Stroke Treatment (TOAST) classification,⁷ and (5) determine selected risk factors, including atrial fibrillation (AF).

Calculations were performed using Excel (Microsoft, Redmond, WA). Standardization was done by the direct method. The study was approved by the Icelandic Data Protection Authority and the National Bioethics Committee.

Results
We identified 410 individuals who presented with first or recurrent stroke during the study period. We excluded the 16% with recurrent stroke, including 4 individuals, who had...
a history of prior stroke symptoms, for which they had not sought medical attention.

The 84% (n=343) who had their first stroke ever during the study period are the index cases of this study. Cause of the stroke was ischemic infarction 81%, intracerebral hemorrhage (ICH) 9%, subarachnoid hemorrhage 7%, and unknown 3%.

Crude incidence for first ever stroke per 100,000 person years of observation, for those aged ≥18 years, was 144 for all; 117 for ischemic infarction, 13 for ICH, 10 for subarachnoid hemorrhage, and 4 for unknown (Tables 1 and 2).

Age-Specific Incidence and Stroke by Subtypes

Imaging Studies
A total of 97% (334/343) had a computed tomography or MRI at the time of diagnosis. MRI was normal in 4% (8/201) of all studied with MRI or 2% (8/343) of all with first stroke.

Pathogenic Classification for Ischemic Stroke (TOAST)
Large artery disease was diagnosed in 7% (20/279), cardioembolic stroke in 36%, lacunar stroke in 12%, other known causes in 2%, and undetermined in 42%.7 The undetermined were fully investigated in 59% (70/118), that is, brain imaging, 24-hour ECG, and carotid imaging; 41% were not fully investigated (all had brain imaging but only some had 24-hour ECG or carotid imaging). Individuals with very large infarcts or with lacunar infarcts were less likely to be fully studied.

Age and Sex
For Ischemic infarction, ICH, and unknown stroke men were 50% (161/320) and women 50%. Mean age at presentation was 71 years for men and 73 years for the women. For subarachnoid hemorrhage, men were 35% (8/23), women 65%, and mean age at presentation was 51 years for all.

Atrial Fibrillation
AF was known before the stroke in 18% and was discovered in another 6% (19/320) on a routine admission ECG. Twenty-four-hour ECG was performed in 63% (154/245) of the remainder (n=245), with ischemic infarction, ICH, or unknown.

Table 1. Annual Incidence Rates of First Ever Stroke (Per 100 000 Population)

<table>
<thead>
<tr>
<th>Age Group, y</th>
<th>Population</th>
<th>Men</th>
<th>Women</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Incidence</td>
<td>n</td>
<td>Incidence</td>
</tr>
<tr>
<td>18–39</td>
<td>103640</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>40–44</td>
<td>22967</td>
<td>4</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>45–49</td>
<td>22720</td>
<td>13</td>
<td>57</td>
<td>0</td>
</tr>
<tr>
<td>50–54</td>
<td>20959</td>
<td>11</td>
<td>52</td>
<td>3</td>
</tr>
<tr>
<td>55–59</td>
<td>17711</td>
<td>18</td>
<td>102</td>
<td>1</td>
</tr>
<tr>
<td>60–64</td>
<td>14254</td>
<td>22</td>
<td>154</td>
<td>3</td>
</tr>
<tr>
<td>65–69</td>
<td>10191</td>
<td>27</td>
<td>265</td>
<td>2</td>
</tr>
<tr>
<td>70–74</td>
<td>8637</td>
<td>49</td>
<td>567</td>
<td>4</td>
</tr>
<tr>
<td>75–79</td>
<td>7874</td>
<td>45</td>
<td>572</td>
<td>8</td>
</tr>
<tr>
<td>80–84</td>
<td>5551</td>
<td>44</td>
<td>793</td>
<td>8</td>
</tr>
<tr>
<td>≥85</td>
<td>4480</td>
<td>43</td>
<td>960</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>238984</td>
<td>279</td>
<td>117</td>
<td>32</td>
</tr>
</tbody>
</table>

*177 per 100,000 when adjusted to 2001 England and Wales population, compared with 162 per 100,000 for the The Oxford Vascular (OXVASC) study.

*142 per 100,000 when adjusted to the 1970 US white population, compared with 145 per 100,000 for the Rochester study.

Table 2. Age-Specific Incidence of Stroke by Subtypes (Per 100 000 Population)

<table>
<thead>
<tr>
<th>Age Group, y</th>
<th>Population</th>
<th>Cerebral Infarction</th>
<th>Intracerebral Hemorrhage</th>
<th>Subarachnoid Hemorrhage</th>
<th>Unknown</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Incidence</td>
<td>n</td>
<td>Incidence</td>
<td>n</td>
<td>Incidence</td>
</tr>
<tr>
<td>18–39</td>
<td>103640</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>40–44</td>
<td>22967</td>
<td>4</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>45–49</td>
<td>22720</td>
<td>13</td>
<td>57</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>50–54</td>
<td>20959</td>
<td>11</td>
<td>52</td>
<td>3</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>55–59</td>
<td>17711</td>
<td>18</td>
<td>102</td>
<td>1</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>60–64</td>
<td>14254</td>
<td>22</td>
<td>154</td>
<td>3</td>
<td>21</td>
<td>2</td>
</tr>
<tr>
<td>65–69</td>
<td>10191</td>
<td>27</td>
<td>265</td>
<td>2</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>70–74</td>
<td>8637</td>
<td>49</td>
<td>567</td>
<td>4</td>
<td>46</td>
<td>0</td>
</tr>
<tr>
<td>75–79</td>
<td>7874</td>
<td>45</td>
<td>572</td>
<td>8</td>
<td>102</td>
<td>1</td>
</tr>
<tr>
<td>80–84</td>
<td>5551</td>
<td>44</td>
<td>793</td>
<td>8</td>
<td>144</td>
<td>1</td>
</tr>
<tr>
<td>≥85</td>
<td>4480</td>
<td>43</td>
<td>960</td>
<td>3</td>
<td>67</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>238984</td>
<td>279</td>
<td>117</td>
<td>32</td>
<td>13</td>
<td>23</td>
</tr>
</tbody>
</table>
Twelve percent (18/154) of the individuals had paroxysmal AF. Thus, AF was present in 29% (94/320) of all with ischemic infarction (31% [87/279]), ICH (18% [6/32]), and unknown cause (11% [1/9]).

**Large Artery Disease**

Carotid arteries were examined in 62% (172/279) of all with ischemic infarction, including ultrasound (58%), computed tomography or MRI angiography (50%). A total of 6% (10/172) of those studied had significant (>70%) symptomatic carotid stenosis.

Studies of intracerebral arteries were performed in 57% (160/279) of those with ischemic infarction; transcranial Doppler 27%; computed tomography or MR angiography 31%. Three percent (4/160) had severe symptomatic stenosis (>50%) of a major intracranial artery.

**Discussion**

We think that we have identified the great majority of strokes in Iceland occurring during the study period, possibly all. We used multiple approaches for identification and most were found by multiple methods. Brain imaging is readily available, and the majority of older infirm people live in nursing homes, which facilitate case ascertainment.

The incidence in our study was similar to the Rochester and The Oxford Vascular OXVASC studies, after standardizing the incidence (Table 1).

AF is a major risk factor for stroke, and 18% of our patients had a known AF at the time of the first stroke, compared with 17% (ischemic infarction) in Rochester and 17% in Ireland (all strokes). Another 12% were found to have AF on routine admission ECG (6%) or 24-hour ECG (6%). Thus, nearly one third of all with ischemic infarction and ICH had AF and half of them were discovered during the admission for the stroke.

This is comparable to 29% with AF in a population sample of first ever stroke in a study from Ireland.

AF is an important potentially treatable risk factor for stroke. Our study suggests that a 24-hour ECG identifies a high number of previously unknown AF, in individuals with first stroke.

**Disclosures**

None.

**References**

Incidence of First Stroke: A Population Study in Iceland
Agust Hilmarsson, Olafur Kjartansson and Elias Olafsson

Stroke. 2013;44:1714-1716; originally published online May 9, 2013;
doi: 10.1161/STROKEAHA.111.000222
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2013 American Heart Association, Inc. All rights reserved.
Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the
World Wide Web at:
http://stroke.ahajournals.org/content/44/6/1714

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published
in Stroke can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office.
Once the online version of the published article for which permission is being requested is located, click
Request Permissions in the middle column of the Web page under Services. Further information about this
process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Stroke is online at:
http://stroke.ahajournals.org/subscriptions/