Prevalence of Silent Stroke in Patients Presenting With Initial Stroke: The Framingham Study

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It is common to find computed tomography scan evidence of prior stroke without a history of such an event. The frequency, risk factors for, and relevance of silent strokes are unknown. The Framingham cohort of 5,184 men and women aged 30–62 years and free of stroke at entry to the study have been followed with periodic examinations since 1950. We studied the silent strokes found on computed tomography scan of all initial strokes that occurred between January 1, 1979, and July 31, 1987. During these 8½ years, 164 initial strokes occurred; 124 had computed tomography scans performed. There were 13 (10%) with silent stroke, 71 had abnormalities related to their presenting acute stroke, and 40 had normal computed tomography scans. There were 15 silent lesions; eight were lacunar infarcts in the basal ganglia–internal capsule area, seven were small cortical infarcts. Glucose intolerance was the sole risk factor that occurred significantly more frequently (11 of 13) in the group with silent lesions (p<0.04) than in the group with computed tomography evidence of acute stroke. Silent stroke is not rare; it was present in at least 10% of acute initial stroke patients arising in a general population. The relation of these silent lesions to the development of "vascular" dementia and poststroke disability deserves further study. (Stroke 1989;20:850–852)

Subjects and Methods

The frequency and characteristics of silent stroke were examined in the Framingham cohort of 5,184 men and women who were free of stroke at entry to the study in 1950. Participants were aged 30–62 years at the initial exam. In addition to a baseline examination, subjects have been examined biennially for 34 years for the development of risk factors and manifestations of cardiovascular disease. Sampling procedures, diagnostic criteria, and methods of examination are described elsewhere.1 On each examination, subjects were routinely queried by a physician concerning habits, medications, and illnesses during the preceding 2 years. Physical examinations and laboratory studies were performed, and details surrounding all interim illnesses were sought.

For stroke and transient ischemic attacks, surveillance was maintained by daily monitoring of all admissions to the only local general hospital (the Framingham Union Hospital). If stroke was suspected, the patient was seen in the hospital by the study neurologist. If neurologic symptoms or signs were noted by the study physician at a routine biennial examination, the subject was referred for

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TABLE 1. Initial Stroke Subtype and Distribution of Cases With Silent Stroke

<table>
<thead>
<tr>
<th>Stroke subtype</th>
<th>No. of cases (%)</th>
<th>No. with silent stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atherosclerotic brain infarction</td>
<td>56 (45.1%)</td>
<td>6</td>
</tr>
<tr>
<td>Cerebral embolism</td>
<td>39 (31.5%)</td>
<td>4</td>
</tr>
<tr>
<td>Lacunar infarct</td>
<td>13 (10.5%)</td>
<td>1</td>
</tr>
<tr>
<td>Intracerebral hemorrhage</td>
<td>11 (8.9%)</td>
<td>2</td>
</tr>
<tr>
<td>Subarachnoid hemorrhage</td>
<td>5 (4.0%)</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>124</td>
<td>13</td>
</tr>
</tbody>
</table>

detailed examination in the neurology clinic. During the period under study, virtually all subjects were admitted to a hospital by their personal physicians when stroke or transient ischemic attack was suspected.

Analyses were restricted to subjects who experienced an initial stroke between January 1, 1979 (the time of first availability of CT technology at the Framingham Union Hospital) and July 31, 1987. Of the 164 initial strokes that occurred in this population, 124 (76%) had CT scans performed at the time of stroke. For each subject, CT scan films or reports obtained at the time of stroke were reviewed for number, type, and anatomy of lesions. For each stroke case with abnormal CT results, physician and hospital notes were reviewed to determine the clinical relevance of CT-documented lesions. Each lesion was then classified as either clinically relevant to the presenting stroke or unrelated to it (i.e., silent).

Prevalence was calculated as the percentage of subjects in the total population who underwent CT examination and had at least one silent lesion. The prevalence of standard cardiovascular risk factors (hypertension, diabetes, cigarette smoking, and glucose intolerance) was routinely assessed before stroke in each of three subgroups in the study population (CT normal, abnormal-relevant, or abnormal with silent lesion[s]). Hypertension was diagnosed when blood pressure values of 160/95 mm Hg or higher were recorded on two successive measurements or if a patient was being treated with antihypertensive medication by a physician. Glucose intolerance was diagnosed if a patient was being treated for diabetes by a physician, if there was glucose in a urine sample tested by Clinitest or Combistix (Ames Division, Miles Laboratories, Elkhart, Indiana), or if glucose measured 120 mg/100 ml or more in a casual blood sample. Statistical analysis was performed with univariate analysis of differences between groups, using a t test for continuous variables and χ² for categoric variables.

**Results**

During the 8½ years under study, 164 initial strokes occurred in the Framingham cohort population. Of these, 124 had a CT scan performed at the time of stroke. The diagnoses of initial stroke subtype are listed in Table 1. In this study group, silent lesions were seen on CT scans of 13 subjects (10.5%), 71 (57.2%) had abnormalities related only to their presenting stroke, and 40 (32.3%) had normal CT scans. In two subjects there were two silent lesions. Of the 15 silent lesions, eight were lacunar infarcts in the basal ganglia–internal capsule area, and seven were small cortical infarcts. No brainstem or cerebellar infarcts were found. The 15 silent infarcts were evenly distributed between the right (eight cases) and left (seven cases) cerebral hemispheres. All deeply situated lesions had diameters of less than 1 cm, whereas the superficial infarcts tended to be larger, and their predominant sites were the occipital lobe (three of seven patients) and the insular cortex (two of seven patients).

The sex and age distribution of the three subgroups did not differ significantly, although it is obviously impossible to determine the age at onset of silent stroke in that subgroup. The groups did not differ with regard to prevalence of hypertension, diabetes, cigarette smoking, or history of prior cardiovascular disease, including a subgroup analysis for those with documented atrial fibrillation. However, glucose intolerance was significantly more prevalent in the silent stroke group than in the normal CT group (84.6% vs. 55.0%); however, this difference did not reach significance (p=0.056).**

**Discussion**

Our findings indicate that silent cerebral infarction occurs fairly frequently (10%) among subjects from a general population investigated for acute stroke symptoms. No comparable data are available from other general populations, but similar prevalence figures (11%) have been reported from the non–population-based National Institute of Neurological and Communicative Disorders and Stroke (NINCDS) Stroke Data Bank study of acute hospi-

**TABLE 2. Prevalence of Risk Factors by Computed Tomographic Scan Group**

<table>
<thead>
<tr>
<th></th>
<th>Hypertension</th>
<th>Cigarette smoking</th>
<th>Glucose intolerance</th>
<th>Prior CVD</th>
<th>Atrial fibrillation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silent stroke (N=13)</td>
<td>76.9%</td>
<td>53.8%</td>
<td>84.6%* (30.8%)</td>
<td>7.7%</td>
<td>23.1%</td>
</tr>
<tr>
<td>Abnormal-relevant (N=71)</td>
<td>73.2%</td>
<td>59.1%</td>
<td>53.5% (21.1%)</td>
<td>14.1%</td>
<td>23.9%</td>
</tr>
<tr>
<td>Normal CT (N=40)</td>
<td>65.0%</td>
<td>60.0%</td>
<td>55.0%† (20.0%)</td>
<td>17.5%</td>
<td>12.5%</td>
</tr>
</tbody>
</table>

Percentages within parentheses indicate diabetes diagnosed by physician. CVD, cardiovascular disease.

*p=0.037, silent vs. abnormal-relevant.

†p=0.056, silent vs. normal CT.
talized stroke patients. Furthermore, in selected groups of patients at high risk for cerebral infarction, such as those with atrial fibrillation, even higher prevalence rates of silent infarction (13%, 48%, 58%) have been reported. Our data represent a conservative estimate of the prevalence of silent stroke in the general population at risk of stroke, since the study was limited to individuals presenting with an acutely symptomatic stroke who were evaluated by head CT scan. No systematic CT scan evaluation of fully neurologically asymptomatic members of this cohort has been done to determine the true prevalence of silent stroke. Such an effort would be required to determine the true fraction of strokes that are silent.

The anatomic features of the silent infarcts that we report here probably explain their being unreported as prior stroke. The features shared by all these lesions included small size and location in brain areas likely to be asymptomatic or minimally symptomatic in the event of acute infarction. Eight of the 15 lesions found on CT scan were lacunar infarcts in the basal ganglia or internal capsule area. Small infarcts limited to the basal ganglia are frequently asymptomatic, and the same applies to capsular lesions that involve its anterior limb and genu, with sparing of the corticospinal tract located in the posterior portion of its posterior limb. The seven cortical infarcts were also of small size (<3 cm in maximal diameter), and they were located primarily in the occipital lobe and insular cortex, with an even right-left distribution. No infarcts were found in the language areas of the dominant hemisphere or in the corticospinal pathways of either cerebral hemisphere. These findings suggest that the silent character of these lesions relates either to their small size and location in truly silent brain areas or to their production of a minor deficit (such as a quadrantanopsia, expected in patients with small occipital infarcts) that may have gone undetected by the patient.

The risk factor profile of this small group of patients with silent stroke revealed a lack of statisti
cally significant aggregation of stroke risk factors as compared with the normal CT and abnormal-
relevant CT groups. The only exception was glucose intolerance, which occurred with highest
frequency in the silent stroke group. The former finding is not surprising, since the total population
studied comprised patients presenting with an acute stroke, thus being expected to have similar risk
profiles. The finding of the high prevalence of glucose intolerance in the silent stroke group is more
difficult to explain. Although it may just represent an artificial clustering of cases in the small
sample of patients with silent stroke, the alternative possibility of a significant association of
this variable with small, asymptomatic stroke needs consideration. It is possible that an abnormal glu-
cose metabolism, which promotes small-vessel disease as well as atheroma, may act as an indepen-
dent risk factor that produces small, deep cerebral infarcts as well as cortical infarcts of "thromboem-
bolic" mechanism. For the anatomic reasons given, these lesions are likely to be asymptomatic.
In addition, it can be suggested that hypertension, which is more frequent in diabetics, further
enhances production of small-vessel, deep cerebral infarcts. The potential association of glucose metabolism abnormalities with silent stroke merits further investigation in larger databases.

The role of silent cerebral infarcts in the pro-
duction of vascular or multi-infarct dementia also
deserves investigation. It has been postulated that the cumulative effects of multiple cerebral infarcts can result in multi-infarct dementia. If that is the case, systematic cognitive evaluation of patients with acute stroke should disclose more impair-
ment of intellectual performance in those also
affected by preexisting cerebral infarcts, either
symptomatic or silent. Such data should help
define the clinical and CT scan parameters associ-
ated with dementia in stroke patients.

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