Community Hospital-Based Stroke Programs in North Carolina, Oregon, and New York

IV. Stroke Diagnosis and Its Relation to Demographics, Risk Factors, and Clinical Status After Stroke

Bruce M. Coull, MD, Joni K. Brockschmidt, MS, George Howard, DrPH, Caroline Becker, MD, Frank M. Yatsu, MD, James F. Toole, MD, Kenneth R. McLeroy, PhD, and John Feibel, MD

The use of diagnostic tests, the accuracy of stroke type diagnosis, and their relationship to outcome are important from the standpoint of patient management and health care costs. To address this issue, we examined the differences between stroke types in terms of demographics, risk factors, diagnostic tests, and clinical outcome in the 4,129 patients who comprise the Community Hospital-Based Stroke Program. Previous transient ischemic attacks were equally frequent among patients with embolic and those with thrombotic stroke. For all stroke types, previous stroke was as frequent as previous transient ischemic attacks. Hypertension and cardiac disease were the most common risk factors, but 10% of all stroke patients had no recognized risk factors. Intracerebral hemorrhage was most often associated with death (45%). There was a strong direct relation between in-hospital mortality and a decreased level of consciousness at admission. Overall, 30% of patients did not receive a specific stroke type diagnosis; these patients were elderly, usually nonwhite, and often had an altered level of consciousness at admission but had a risk factor profile similar to that of patients who received a specific stroke type diagnosis. In summary, our findings suggest the continued need for physician education about and refinement of stroke type diagnosis.

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gies will not be tailored to an unspecified stroke type. Conversely, the lack of a specific stroke type diagnosis may reflect clinical practicality. Severely afflicted or profoundly debilitated patients have a poor long-term prognosis and there is no effective treatment for them, thereby making aggressive pursuit of a more definitive stroke type diagnosis impractical. We report the results of our investigations into the relations of specific stroke type diagnoses with demographic factors, selected risk factors, the use of certain diagnostic tests, the level of consciousness at hospital admission, and the subsequent discharge disposition.

Subjects and Methods

We used data from the community hospital-based stroke programs of North Carolina, Oregon, and New York. This data base comprises information on 4,129 hospitalized stroke patients. Its details, including the algorithms for the diagnosis of stroke and transient ischemic attack (TIA), have been published.6,12,13 The demographic factors included age, race, and sex; age was grouped as ≤55, 56–65, 66–75, and >75 years. Race was coded as white or nonwhite. The risk factors were hypertension, cardiac disease, diabetes mellitus, previous TIA, and previous stroke; standard criteria were used to define hypertension, cardiac disease, and diabetes mellitus.6 The diagnostic tests included computed tomography of the brain (CT), lumbar puncture, invasive cerebral angiography, radionuclide brain scanning, electrocardiography (ECG), and electroencephalography (EEG). As a measure of severity, level of consciousness at admission was scored for all patients as alert, disoriented/lethargic, or stuporous/comatose. Discharge disposition was categorized as discharge to home, discharge to an institution, or death during initial hospitalization; institutions included rehabilitation institutes as well as long-term nursing care facilities.

Stroke type was categorized as infarction, hemorrhage, or NOS. The first category included the subcategories thrombotic, embolic, and not otherwise specified infarctions. Thrombotic infarction included artery-to-artery embolism as well as lacunar infarction, while embolic infarction was confined to cardioembolism. Infarction not otherwise specified could be thrombotic, cardioembolic, or lacunar. The second category included the subcategories intracerebral hemorrhage (ICH), subarachnoid hemorrhage (SAH), and hemorrhage not otherwise specified. The stroke NOS category comprised patients in whom the diagnosis was not further refined and did not distinguish infarction from hemorrhage as a cause for the neurologic deficit. Many such cases were reviewed by neurologists associated with the Community Hospital–Based Stroke Program to confirm that insufficient data were available for a more definitive diagnosis.

The various demographic, risk factor, severity, and outcome measures as well as the diagnostic tests performed during hospitalization were tabulated as frequencies by stroke type. As is common in studies of this size, data on all variables were not available for all subjects. The tables include the denominators from which the particular percentages were calculated. Due to the large number of observations, many relations may be statistically significant and yet have little clinical significance. In addition, numerous tabulations were compiled for this publication, and if each were tested statistically many would be significant by chance alone. For these reasons, we generally avoided tests for statistical significance. Instead, points of clinical interest and possible significance are highlighted in the “Results” and “Discussion” sections.

Despite the fact that we analyzed the detailed stroke type subcategories thrombosis, cardioembolism, and infarction not otherwise specified; ICH, SAH, and hemorrhage not otherwise specified; and stroke NOS, generally we present the data by the more gross stroke type categories infarction, hemorrhage, and stroke NOS. However, when, in the opinion of the authors, the more detailed subcategorization gives more insight into the disease process, results from the detailed analyses are provided.

Results

Figure 1 shows the number of patients in each stroke type category by age group. Infarction was the most frequent stroke type for all age groups, and the incidences of both infarction and stroke NOS increased with age. While the number of patients with hemorrhagic stroke was constant across age groups, SAH occurred more frequently in the younger patients whereas the incidence of ICH increased in the older age groups. For all but the youngest age group, stroke NOS was more prevalent than hemorrhagic stroke. Although stroke NOS was seen most frequently in the elderly, 25% of individuals diagnosed as having stroke NOS were ≤65 years old and the proportions aged ≥66 years were similar for infarction and stroke NOS (72% and 75%, respectively). As shown in Table 1, half of the patients with embolic infarction were in the oldest age group, whereas SAH was clearly most frequent in the youngest age group.
TABLE 1. Percent of Patients in Each Age Group by Stroke Type Subcategory

<table>
<thead>
<tr>
<th>Subcategory</th>
<th>Age group (yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤55 (%)</td>
</tr>
<tr>
<td>Infarction</td>
<td></td>
</tr>
<tr>
<td>Thrombotic</td>
<td>1,340</td>
</tr>
<tr>
<td>Embolic</td>
<td>443</td>
</tr>
<tr>
<td>Not otherwise specified</td>
<td>670</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td></td>
</tr>
<tr>
<td>Intracerebral</td>
<td>202</td>
</tr>
<tr>
<td>Subarachnoid</td>
<td>89</td>
</tr>
<tr>
<td>Not otherwise specified</td>
<td>123</td>
</tr>
<tr>
<td>Not otherwise specified</td>
<td>1,241</td>
</tr>
</tbody>
</table>

Race and sex of the patients by stroke type categories are illustrated in Table 2. The percentage female in each category was roughly equal to the overall proportion of females in the data base (53%). However, most (63%) of the 89 patients with an SAH were female, and a surprising proportion (59%) of the 443 with embolic infarction were female. The proportions of nonwhites experiencing hemorrhagic stroke and stroke NOS were approximately double that experiencing infarction. Of nonwhites, most (>90%) were black.

Figure 2 shows the relations between selected risk factors and stroke type category. By subcategories, hypertension was almost equally frequent among those with thrombotic infarction (60%) and ICH (63%) but was least frequent among those with SAH (39%) (data not shown). A recognizable cardiac disease was identified in 88% of those in whom embolic infarction occurred (data not shown), although this may be somewhat circular since cardiac disease is a factor identifying embolic infarction. The frequency of diabetes mellitus was similar among those with hemorrhagic strokes and infarctions. Previous stroke occurred as frequently as previous TIA (23%) among patients with infarction. By subcategory (Table 3), previous TIA and previous stroke were both equally frequent among patients with thrombotic and embolic infarction. At least one risk factor was present in almost all patients (90% among those with infarction, 75% among those with hemorrhages, and 87% among those with stroke NOS). Except for hypertension, each risk factor was more frequent among patients with infarctions or stroke NOS than among patients with hemorrhages.

Figure 3 shows the frequency of the use of diagnostic tests by stroke type category. A high percentage of the patients who received a specific stroke type diagnosis underwent CT; 83% of those diagnosed as having ICH and 78% of those diagnosed as having SAH (data not shown) received at least one CT scan. Interestingly, 15% of patients eventually receiving a diagnosis of stroke NOS had a CT scan. Among patients with infarction, angiography was less frequently utilized than radionuclide brain scanning or EEG, but 62% of those diagnosed as having a SAH underwent cerebral angiography (data not shown).

ECG was performed in a high percentage of all patients. Considering only the diagnostic tests recognized as more informative (CT, lumbar puncture, and angiography) in general patients with hemorrhagic strokes were more aggressively evaluated than those with infarction or stroke NOS.

Figure 4 shows the level of consciousness at admission by stroke type category. Persons with infarction were most often alert, whereas those with hemorrhagic stroke had the highest percentage stuporous/comatose at admission (43%). This percentage was similar for patients with ICH and SAH (41% and 39%, respectively; data not shown). Forty-six percent of those diagnosed with stroke NOS were fully alert at admission, but stupor/coma was more than twice as common in those with stroke NOS as in those with infarction.

Figure 5 shows discharge disposition by stroke type category. Patients with hemorrhagic stroke had the greatest percentage of in-hospital deaths, with a slightly higher mortality for ICH than for SAH (Table 4). In contrast, only 14% of those with infarction died during the initial hospitalization. Additionally, 43% of the patients with stroke NOS were discharged home compared with 60% of those with thrombotic infarction (Table 4).

Discussion

Many aspects of the Community Hospital–Based Stroke Program data agree with those in other published series. For example, the proportions of patients with thrombotic or embolic infarctions are similar to those reported from the National Survey of Stroke and the Framingham Study. Other studies have found similar frequencies for gender among patients with brain infarctions as well as the preponderance of females >40 years old with SAH. The Community Hospital–Based Stroke Program's data base, like

<table>
<thead>
<tr>
<th>Category</th>
<th>n</th>
<th>Nonwhite (%)</th>
<th>Female (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infarction</td>
<td>2,456</td>
<td>11</td>
<td>53</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>414</td>
<td>19</td>
<td>56</td>
</tr>
<tr>
<td>Not otherwise specified</td>
<td>1,238</td>
<td>23</td>
<td>53</td>
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FIGURE 2. Bar graph of percent of stroke patients with selected risk factors (TIA, transient ischemic attack) by stroke type category (open bars, infarction; shaded bars, hemorrhage; filled bars, stroke not otherwise specified, Note approximately identical percentages with hypertension for each stroke type. Almost all patients had one or more risk factor.

TABLE 3. Percent of Patients With Previous Cerebrovascular Events by Stroke Type Subcategory

<table>
<thead>
<tr>
<th>Subcategory</th>
<th>Previous event</th>
<th>Transient ischemic attack</th>
<th>Stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Infarction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thrombotic</td>
<td>1,136</td>
<td>28</td>
<td>1,274</td>
</tr>
<tr>
<td>Embolic</td>
<td>363</td>
<td>25</td>
<td>421</td>
</tr>
<tr>
<td>Not otherwise specified</td>
<td>574</td>
<td>13</td>
<td>606</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intracerebral</td>
<td>168</td>
<td>10</td>
<td>192</td>
</tr>
<tr>
<td>Subarachnoid</td>
<td>77</td>
<td>4</td>
<td>85</td>
</tr>
<tr>
<td>Not otherwise specified</td>
<td>73</td>
<td>6</td>
<td>119</td>
</tr>
<tr>
<td>Not otherwise specified</td>
<td>532</td>
<td>21</td>
<td>1,172</td>
</tr>
</tbody>
</table>

those of other hospital-based registries,10,11 differs from those of both the Framingham Study4 and the Stroke Data Bank15 in terms of ICH, which we found to be twice as frequent as SAH. The reasons for this difference are not clear, but it could be due to the hospital basis for our study. As in the Stroke Data Bank, our data show an increasing proportion of persons >75 years old with cardioembolism. This is in contradistinction to the general emphasis on cardioembolism as a primary cause of stroke in young adults.17,18 In part, these data may be explained by a preponderance of females in the older age groups. In general, cardioembolic infarction appears to be more severe than thromboembolic infarction since a greater proportion with the former had altered levels of consciousness at admission (data not shown) and correspondingly a greater likelihood of dying during the initial hospitalization.

Similar agreement for the risk factor data exists with other epidemiologic studies. Hypertension was present in the same proportion of patients across stroke type categories, with only the subcategory SAH showing a slightly decreased incidence. The incidence of cardiac disease was practically identical to that of hypertension, especially among patients with infarction. This suggests that cardiac disease as a link to all forms of infarction bears emphasis. The incidence of diabetes mellitus was similar to that reported from the National Survey of Stroke5 as well as by Mohr et al for the Harvard Cooperative Stroke Registry.10 We, however, found a 15% incidence of diabetes mellitus among patients with SAH (data not shown), which is relatively high compared with only 2% in the Harvard Cooperative Stroke Registry.10 The incidence of diabetes mellitus was highest in persons who experienced thrombotic infarction (data not shown) or stroke NOS. Contrary to the suggestion of Plum19 and others,20,21 the frequency of TIA was not reduced in persons with diabetes mellitus; 148 of 698 known diabetics (21%) and 457 of 2,175 known non-diabetics (21%) reported previous TIA.

If considered as a risk factor, previous stroke occurred as frequently as previous TIA. This is particularly impressive since many previous strokes were surely fatal. Moreover, both previous TIA and previous stroke were encountered as frequently in patients with embolic infarction as in those with thrombotic infarction. This was also true in the Stroke Data Bank.15 The incidence of previous TIA among those experiencing embolic stroke in the Community Hospital-Based Stroke Program (25%) is more than double that reported from the Michael Reese Stroke Registry (11%).22 This may be explained in part by the differing proportions of nonwhites: 3% (14 of 443) among our patients and 66% in the Michael Reese Stroke Registry. Gorelick et al,23 in a study of 26 white and 45 black patients, found significantly more TIA among the white patients. For all patients with cerebral infarction in general, the incidence of previous stroke and TIA appears to be twice that reported for community-based studies but very similar.
to that reported by others\textsuperscript{10,24} for thromboembolic infarction alone. These data confirm the importance of previous stroke as well as previous TIA for recurrent events. In particular, the predilection for stroke recurrence has been emphasized by others\textsuperscript{5,25,26} and certainly bears continued study from the standpoint of mechanism and therapeutic intervention.

A somewhat unexpected finding was that only 14\% of the patients with infarction underwent cerebral angiography; this utilization rate was less than that for lumbar puncture, radionuclide brain scanning, and EEG. Even assuming that a high percentage of the cerebral angiograms would have identified surgically accessible lesions, these data suggest that the impact of surgery on the overall population of persons suffering stroke is small.

As anticipated, the use of CT had a strong impact on establishing specific stroke type diagnoses. The effects of this technology, however, remain to be better defined since 15\% of individuals whose diagnosis was not refined beyond stroke NOS received CT. This nonspecific diagnosis may result from physicians' reluctance to use a refined stroke type diagnosis or from a lack of interest in recording such a diagnosis in the medical records. The fact that the frequency of stroke NOS in our study was lower than that in the National Survey of Stroke\textsuperscript{5} while the frequency of CT use was higher suggests that CT has led to more "specific" stroke type diagnoses. Our study was conducted before sophisticated noninvasive testing procedures, such as intravenous digital subtraction angiography, magnetic resonance imaging, and B-mode echo imaging, became widely available. Biller et al\textsuperscript{27} believe that the use of procedures such as echocardiography and cardiac magnetic resonance imaging will further reduce the number of
infarctions not otherwise specified. Anderson and Fischer\(^2\) have suggested that digital subtraction arteriography will markedly reduce the use of conventional arteriography and possibly alter the role of the traditional noninvasive tests. However, the impact of the wider use of such procedures remains speculative.

There was an apparent correlation between the level of consciousness at admission and discharge disposition. For example, among patients with infarction, 13% were stuporous/comatose at admission and 14% died during the initial hospitalization. As expected, these percentages were higher for those with hemorrhagic stroke; 43% of such patients were stuporous/comatose at admission and 38% died during the initial hospitalization. Our data do not assure a one-to-one correlation between the level of consciousness at admission and outcome, and it is likely that some patients changed categories in both directions, but the overall trend agrees with the published experience of the Cornell Medical Center\(^2\) and others.\(^3,8\) Among infarctions, cardioembolism resulted in the most in-hospital deaths (23%). This mortality probably relates to both severity of the stroke and the underlying cardiac disease itself.

Overall, ICH had the worst prognosis, with 45% dying during the initial hospitalization.

Within the Community Hospital-Based Stroke Program data base, patients categorized as having stroke NOS fell between the extremes defined by the infarction and hemorrhagic categories. Patients with stroke NOS tended to be older (75% were > 66 years old), and a great proportion were nonwhite. Their risk factor profile was similar to that of patients with a specific stroke type diagnosis, but fewer diagnostic tests were performed in them. This lack of evaluation appears not to reflect simple pragmatism and cannot be attributed to severity of the stroke. Roughly one quarter were < 65 years old, approximately half were fully conscious at admission, and 43% were discharged home. Presumably, then, a number of these younger individuals with stroke NOS were minimally or only mildly affected by their stroke. The stroke NOS category comprised almost one third of the data base, and to our viewpoint this lack of specific stroke type diagnosis represents an important problem in stroke prevention and therapy.

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**References**


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