Association of Stroke With Dementia, Cognitive Impairment, and Functional Disability in the Very Old
A Population-Based Study

Li Zhu, MD; Laura Fratiglioni, MD, PhD; Zhenchao Guo, MD, PhD; Hedda Agüero-Torres, MD, PhD; Bengt Winblad, MD, PhD; Matti Viitanen, MD, PhD

Background and Purpose—Stroke is a major cause of disability in the elderly and is also related to the development of dementia, which is another important source of disability in old age. The aim of the present study was to examine the potential impact of stroke on cognitive and functional status in a community-based cohort of individuals aged 75 years and older.

Methods—The data were derived from a cross-sectional survey on aging and dementia that included all inhabitants of the Kungsholmen district in central Stockholm who were aged ≥75 years. Cases of stroke were identified through the computerized inpatient register system that has been widely used to study stroke in Sweden. Dementia was defined according to the Diagnostic and Statistical Manual of Mental Disorders, Third Edition, Revised. Dementia onset was considered the appearance, according to an informant, of the first symptom. Cognitive impairment without dementia was defined as the presence of a Mini-Mental State Examination score of $24 and the absence of dementia. Functional disability was assessed according to Katz Index of independence in activities of daily living.

Results—The prevalence of stroke was 10.0% in men and 8.0% in women. One third of stroke survivors were diagnosed as demented, which was 3 times higher than those without stroke: adjusted odds ratio (OR) was 3.6 (95% confidence interval, 2.5 to 5.8). Stroke was also significantly related to cognitive impairment without dementia (adjusted OR, 2.4 [95% confidence interval, 1.3 to 4.6]). The population-attributable risks of dementia and cognitive impairment in relation to stroke were 18.4% and 8.5%, respectively. Among the 49 stroke patients with dementia, 15 cases (30.6%) had missing information on dementia onset, 22 (44.9%) had been reported by the informant to have dementia-related symptoms after or close to the occurrence of stroke, and 12 (24.5%) had symptoms before stroke occurrence. The prevalence rates of disability in activities of daily living were much higher among stroke patients than among stroke-free subjects, even after adjustment for age, sex, heart disease, hip fracture, and dementia: the corresponding adjusted ORs for bathing, dressing, toileting, transfer, and continence were 3.5 (2.4 to 5.3), 2.2 (1.4 to 3.3), 3.0 (2.0 to 4.5), 3.3 (1.9 to 5.7), and 2.1 (1.3 to 3.3), respectively. After dementia and hip fracture, stroke was the third largest contributor to disability in bathing, dressing, and transfer. Stroke was the second contributor to disability in toileting.

Conclusions—Stroke is strongly associated with dementia, although it may relate to dementia in different ways: it can be the main cause or a precipitating factor of dementia, or they may share common etiological bases. Together with dementia and hip fracture, stroke is a major contributor to disability in most aspects of activities of daily living in very old people. (Stroke. 1998;29:2094-2099.)

Key Words: aging ■ cognitive impairment ■ dementia ■ disability ■ stroke

Stroke is a major cause of disability in the elderly in many Western societies.1–3 It is also related to the development of dementia,4–10 which is another important source of disability in old age.11 Relatively few studies have been conducted to estimate the prevalence of stroke in the general population.12–14 Available data about the relationship between stroke, dementia, and disability are mostly derived from clinic-based observations. In addition, no studies have specifically targeted persons aged ≥75 years, which is not only the most rapidly increasing segment of industrialized population but also the age range that is more often and more severely affected by stroke, dementia, and disability.

The aim of the present study was to examine the association of stroke with dementia, cognitive impairment, and functional disability in the very old by using data from a community-based cohort of individuals aged ≥75 years.

Subjects and Methods

The data for this study were derived from a cross-sectional survey on aging and dementia that included all inhabitants of the Kungsholmen district in central Stockholm who were aged ≥75 years.
In phase II, all subjects who screened positive (MMSE score of 24) were considered prevalent stroke cases. In Sweden, >90% of patients who suffer from a stroke are admitted to a hospital.

Most of the stroke patients who are not hospitalized are those who die at home or on the way to the hospital. This will not affect our results of the prevalence of stroke. A previous study which examined the validity of the register data on stroke reported that 94% of hospitalized stroke patients were classified correctly. All kinds of heart disease (ICD-8 codes 390 to 429), cancer (ICD-8 codes 140 to 208 and 230 to 239), and hip fracture (ICD-8 code 820) were detected from the same register data.

Cognitive performance was indexed with the Mini-Mental State Examination (MMSE). Dementia cases were detected by means of a 2-phase study design: a screening phase (phase I) and a clinical examination and diagnostic procedure have been reported elsewhere.

Briefly, diagnoses were performed in 3 steps. First, a screening test was performed. In Sweden, >90% of patients who screened positive (MMSE score of <24; suspected to be affected by dementia; n=314) and a sample of subjects who screened negative (MMSE score of ≥24; not suspected to be affected by dementia; n=354) were clinically examined. A diagnosis of dementia was made according to the Diagnostic and Statistical Manual of Mental Disorders, Third Edition, Revised (DSM-III-R).

The cognitive examination explored memory functions by asking facts of general knowledge and past personal information, language functions by object naming and comprehension, abstract thinking by problem solving and proverbs, praxis function by examining simple motor activities (dressing, pantomime), and visuospatial skills by copying figures. Details of the clinical examination and diagnostic procedure have been reported elsewhere. Briefly, diagnoses were performed in 3 steps. First, a preliminary diagnosis was given by the examining physician. Second, all cases were independently reviewed by a neurologist (L.F.), and a second preliminary diagnosis was made. In case of agreement between the first and the second diagnosis, this was the final diagnosis. Third, in case of disagreement, a third opinion was asked, and the concordant diagnosis was accepted. For patients with aphasia, a close informant was asked about a patient’s everyday behavior and activities of daily living. If the patients were thought to be behaviorally unchanged and routinely attempted to use their residual functions, they were not considered demented. The age of first symptoms of dementia was estimated with information provided by an informant. Duration of the disease was based on the difference between the date of the appearance of dementia-related symptoms and the date of the screening test. Cognitive impairment without dementia was defined as the presence of an MMSE score <24 and the absence of dementia, which is similar to the definition described by Graham and coworkers.

Functional disability was assessed according to Katz Index of independence in activities of daily living (ADL). The subjects were asked questions regarding their ability to bathe, dress, go to toilet, transfer, maintain continence, and feed. Any dependent performance of these activities was recorded as disability in correspondent items.

Information on drug use was collected for the 2 weeks preceding the interview. Use of both prescription and nonprescription drugs was queried, and drug containers were inspected to verify this information. The survey also included measurement of blood pressure. A clearly abnormal blood pressure was defined if the subject could not answer the questions adequately. Data on ADL status and drug use were gathered from proxies for 10.7% of the participants.

**Results**

The mean age of the study population was 82.5 years (SD, 5.2), and 76.1% were women. Of the 1810 subjects, 53.0% had an educational attainment of <8 years (only 2 persons had <4 years of education), 13.4% had a history of heart disease, 11.9% had some type of cancer, 10.8% had a history of hip fracture, and 43.1% took antihypertensive medication.

In terms of blood pressure, 44.5% had systolic pressure of 140 to 160 mm Hg, and 13.4% had diastolic pressure of ≥160 mm Hg, and 13.4% had diastolic pressure of ≥95 mm Hg.

Of the 153 persons with a history of stroke, 11 (7.2%) were recorded as having hemorrhagic stroke (ICD-8 codes 430 and 431). At the interview, 58.2% (n=89) of the stroke patients had survived for >3 years, 37.9% (n=58) for >5 years, and 14.4% (n=22) for >10 years. The prevalence of stroke in men was higher than in women except for the age group 80 to 84 years (Table 1). The prevalence of stroke increased with age, especially in women.

We detected 225 cases of dementia (121 cases of Alzheimer’s disease, 52 of vascular dementia, 3 of mixed dementia, 21 of secondary dementia, 14 of uncertain type dementia, and 14 cases of questionable dementia). The prevalence of dementia was higher among stroke patients (32.0%) than among individuals with no history of stroke (10.6%; P<0.0001). Among stroke cases, 11 of the 43 men and 38 of the 110 women were demented (P=0.38). Demented stroke patients were older than nondemented stroke patients (mean age, 85.8 versus 83.7 years; P=0.03). Among the 49 stroke patients with dementia, 15 (30.6%) had missing information on dementia onset, 22 (44.9%) had been reported by the informant to have had dementia-related symptoms after or close to the occurrence of stroke, and 12 (24.5%) had symptoms before stroke occurrence.

**Statistical Analysis**

The prevalence rates of stroke (cases per 100 subjects) were calculated in 3 different age groups according to sex. The 95% confidence intervals (CIs) of the prevalence rates were calculated using the approximated formula based on the normal distribution. We used logistic regression analysis to examine the association of stroke with dementia and disability. When the relationship between stroke and dementia was examined, we considered age (continuous variable), sex (male versus female), education (<8 versus ≥8 years), heart disease (yes versus no), systolic blood pressure (2 indicator variables, one indicating systolic pressure of <140 mm Hg and the other systolic pressure ≥160 mm Hg), compared to the reference group with systolic pressure of 140 to 160 mm Hg), and antihypertensive drug use (yes versus no) as potential confounders. We adjusted all these covariables by including the variables in the logistic model. When the association between stroke and disability was analyzed, age (per 5 years), sex (male versus female), education (<8 years versus ≥8 years), heart disease (yes versus no), cancer (yes versus no), hip fracture (yes versus no), and dementia (yes versus no) were considered with use of a forward stepwise procedure.

We calculated population-attributable risk percentage (PAR%) with the following formula: PAR% = [(r-1)/(1+(r-1))] * 100%, where p is the proportion of a certain factor in the whole study population and r is the odds ratio (OR) from the models where all significant covariables were included. PAR% can be defined as the proportion of all cases of the disease or condition that may be attributable to the factor. In this study, we used PAR% to describe the potential contribution of stroke to dementia and disability in ADL.
The crude OR of dementia in relation to stroke was 4.0 (95% CI, 2.7 to 5.8), which became 3.6 (95% CI, 2.3 to 5.5) after adjustment for age, sex, education, systolic blood pressure, heart disease, and antihypertensive drug use (Table 2). When the 12 patients who had been reported to have dementia-related symptoms before the occurrence of stroke were excluded, the OR of dementia in relation to stroke was 3.0 (2.0 to 4.5). Stroke was also related to the increased OR for cognitive impairment without dementia (crude OR, 2.6 [95% CI, 1.4 to 4.7]). The relation between stroke and cognitive impairment did not change after adjustment for the potential confounders (Table 2).

The prevalence rates of disability in bathing, dressing, toileting, transfer, and continence were 22.5%, 16.4%, 15.3%, 6.6%, and 9.7%, respectively, in the entire population. There were 80 subjects (4.4%) who had disability in all items. Disability in feeding was not shown because only 46 persons (2.5%) were recorded as having feeding dependence. There was no significant difference in the prevalence of disability in most items between stroke patients who survived >3 years and those who have survived for <3 years.

Table 3 shows the ORs of disability associated with age (per 5 years), sex, heart disease, hip fracture, dementia, and stroke, where all the covariates were considered by using a forward stepwise procedure. Age, heart disease, hip fracture, dementia, and stroke were consistently related to disability in all aspects, while male sex was only related to disability in dressing. Dementia produced the largest OR of disability in all aspects.

Table 4 shows the population-attributable risk percentages of dementia, hip fracture, stroke, and heart disease to disability. Dementia was the biggest contributor to disability, which was responsible for almost 50% of disability in bathing, transfer, and toileting and for nearly 10% of disability in dressing and continence. After dementia and fracture, stroke was the third largest contributor to disability in bathing, dressing, and transfer. Stroke was the second biggest contributor to disability in toileting, and the fourth contributor to disability in continence.

At the screening stage, we tried to get the information on ADL status from the informants for those with suspected cognitive dysfunction. There were still 74 dementia patients whose data about ADL status were self-reported. However, inclusion of a variable indicating the data sources in the analysis or exclusion of those patients with dementia did reduce the ORs of disability in ADL in relation to dementia but did not significantly change the ORs of disability in relation to stroke.

Discussion

The main findings of this study concern 3 aspects: the prevalence of stroke, the relation between stroke and dementia, and the contribution of stroke to disability. These topics will be discussed separately.

Prevalence of Stroke

Information on the prevalence of stroke were often obtained from self-reports in previous surveys.\cite{12-18} The accuracy of this data source has been confirmed to be very high in middle-aged persons.\cite{20} However, self-reported data on stroke may be questionable in the very old, because a considerable proportion of people in this age group are cognitively impaired. The

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TABLE 3. Major Predictors of Disability*

<table>
<thead>
<tr>
<th></th>
<th>Bathing</th>
<th>Dressing</th>
<th>Toileting</th>
<th>Transfer</th>
<th>Continence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (per 5 y)</td>
<td>1.5 (1.3–1.7)</td>
<td>1.3 (1.1–1.5)</td>
<td>1.6 (1.4–1.8)</td>
<td>1.6 (1.3–1.9)</td>
<td>1.4 (1.2–1.7)</td>
</tr>
<tr>
<td>Male sex</td>
<td>1.7 (1.2–2.3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart disease</td>
<td>1.8 (1.3–2.6)</td>
<td>1.6 (1.1–2.3)</td>
<td>2.0 (1.4–2.8)</td>
<td>2.1 (1.3–3.5)</td>
<td>2.2 (1.4–3.3)</td>
</tr>
<tr>
<td>Hip fracture</td>
<td>3.4 (2.3–4.9)</td>
<td>3.4 (2.3–5.0)</td>
<td>2.3 (1.6–3.4)</td>
<td>4.0 (2.4–6.4)</td>
<td>2.1 (1.3–3.2)</td>
</tr>
<tr>
<td>Dementia</td>
<td>8.6 (6.1–12.2)</td>
<td>8.7 (6.2–12.2)</td>
<td>5.3 (3.7–7.4)</td>
<td>10.3 (6.5–16.3)</td>
<td>6.2 (4.2–9.0)</td>
</tr>
<tr>
<td>Stroke</td>
<td>3.4 (2.3–5.1)</td>
<td>2.2 (1.4–3.4)</td>
<td>3.0 (2.0–4.5)</td>
<td>3.3 (2.0–5.7)</td>
<td>2.1 (1.3–3.3)</td>
</tr>
</tbody>
</table>

*OR (95% CI) from logistic regression models using a forward stepwise procedure; education and cancer were considered as well.

TABLE 4. Population-Attributable Risk Percentages (PAR%) of Dementia, Hip Fracture, Stroke, and Heart Disease to Disability*

<table>
<thead>
<tr>
<th>Disability</th>
<th>Dementia</th>
<th>Hip Fracture</th>
<th>Stroke</th>
<th>Heart Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bathing</td>
<td>48.7</td>
<td>20.5</td>
<td>17.1</td>
<td>10.0</td>
</tr>
<tr>
<td>Dressing</td>
<td>48.9</td>
<td>20.6</td>
<td>9.2</td>
<td>7.4</td>
</tr>
<tr>
<td>Toileting</td>
<td>34.7</td>
<td>24.3</td>
<td>16.6</td>
<td>12.9</td>
</tr>
<tr>
<td>Transfer</td>
<td>53.6</td>
<td>10.4</td>
<td>8.4</td>
<td>13.6</td>
</tr>
<tr>
<td>Continence</td>
<td>39.2</td>
<td></td>
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</table>

*Based on the ORs listed in Table 3.

age- and sex-specific prevalence rates of stroke in our study are similar to those reported in studies based on self-reported data\(^2,14,17\) as well as a report from population-based stroke registers.\(^30\) The prevalence of stroke increases with age and male sex. Our data generally follow this pattern. In our study, the lower prevalence of stroke in men 80 to 84 years of age may reflect a survival variation rather than a risk difference.

Inpatient register data have been widely used to study stroke in Sweden.\(^20,31–33\) It has been estimated that fewer than 10% of stroke patients may have been omitted by the register during the 1980s.\(^30\) We believe that the number of stroke cases recorded in our study may be underestimated by the register.\(^6\) The mechanisms underlying this association may be multiple.\(^8,35\) First, stroke can be the direct or main cause of death.\(^8,36\) Third, stroke and dementia may share common environmental factors and biological bases, such as apolipoprotein e4 allele.\(^8,37\) Several factors have been found to be related to dementia with stroke or multiple cerebral infarcts.\(^38,39\) Finally, the vascular lesion in the brain, including white matter changes, Alzheimer’s degenerative lesions, and even aging itself, may have an additive effect on the development of dementia.\(^35\)

In this study we examined the cross-sectional association between stroke and dementia and found that 32% of stroke survivors (mean age, 84.4±5.5 years) were diagnosed as demented. By using the same criteria (DSM-III-R), Principe and colleagues\(^46\) showed in a sample with a median age of 77 years that 30% of stroke survivors were demented. Hénon and coworkers\(^8\) reported a very similar figure (32.4% according to DSM-IV criteria). The frequency of dementia was 32% in the group aged 75 to 85 years in the study by Pohjasvaara et al\(^9\) and 31% in the group aged 75 to 79 years in the study by Tatemichi et al\(^2\), although the overall frequency of dementia was slightly lower than 30% in these 2 samples of stroke patients. However, the frequency of dementia in stroke patients was 13.6% in a sample with a mean age of approximately 65 years.\(^2\) Further, we found that patients with stroke had a nearly fourfold higher probability of being diagnosed with dementia than those without stroke, and we estimated that stroke accounted for 18% of the prevalence of dementia in this population. Our results, which were adjusted for a number of potential confounders, may accurately represent the strength of the association between stroke and dementia in the general population because of our choice of sampling procedures and diagnostic evaluation.

Due to the nature of the study, we cannot regard the association only as causative. In fact, as reported by Hénon et al\(^9\) in a recent study, stroke patients may have preexisting dementia. We found that more than 20% of the stroke patients (n=12) who were diagnosed as demented had dementia-related symptoms before the occurrence of stroke, according to an informant. This finding supports the hypothesis that the presence of stroke precipitates the onset of dementia or Alzheimer’s disease. There is no evidence supporting the opposite interpretation, that dementia or Alzheimer’s disease increases the risk of stroke, although the recurrence of stroke is higher in stroke patients with dementia than in those without dementia.\(^40\) However, there was a strong relationship between stroke and dementia even when the 12 patients with dementia-related symptoms before the occurrence of stroke were excluded from the analyses.

We may have underestimated the relationship between stroke and dementia, because we can identify only clinically overt stroke cases. Silent stroke may be more common than
clinically recognized stroke. A recent longitudinal study provides indirect evidence that silent stroke is an important risk factor for cognitive impairment. A cohort of 5024 subjects aged 71 years and older, who were free of clinically recognized stroke, were followed up for an average of 4.3 years. People with lower scores in a brief cognitive test had a significantly higher risk of developing a clinical stroke. In our study, stroke was also related to cognitive impairment without dementia. Patients with vascular cognitive impairment are probably at an early stage of dysfunction and may be more likely to be prevented from having further deterioration.

Because stroke is one of the criteria for vascular dementia, we did not analyze Alzheimer’s disease and vascular dementia with stroke separately. However, presence of stroke does not affect the diagnosis of dementia. Skoog and colleagues found that dementia with a vascular component comprised nearly half of all dementia cases in a population-based sample aged ≥85 years in Gothenburg, Sweden, which is higher than the proportion of vascular dementia in this study. The high proportion of vascular dementia in the Gothenburg study may result from the use of CT scanning. However, the coexistence of Alzheimer’s disease and vascular changes in pathology is common, and there is a difficulty in deciding which contributes more to the development of dementia. Another explanation for the difference in the prevalence of vascular dementia between these 2 studies could be that the mortality of vascular dementia or stroke might be higher in this population than in the Gothenburg population.

**Stroke and Disability**

Higher prevalence rates of disability in bathing, dressing, toileting, transfer, and continence were found in stroke patients than in stroke-free subjects. Generally, our data agree with previous findings that more than half of stroke survivors have some kind of disability in ADL. The prevalence of disability among stroke patients may depend on the survival time or duration of the disease. We did not find a significant difference in disability between stroke patients who survived ≤3 years and those who survived ≥3 years. After dementia and hip fracture, stroke was the third largest contributor to disability in bathing, dressing, and transfer. Stroke was the second largest contributor to disability in toileting.

Methodological differences have a substantial effect on the prevalence estimates of disability in the elderly. Our data are similar to those of a Finnish study that used the same ADL scale. Our age- and sex-specific prevalence rates of disability are also very close to those of a large-scale study in United States, despite methodological differences. We demonstrated that age continues to be a strong predictor of disability in all aspects. Interestingly, men were more likely than women to be dependent in dressing.

The Katz ADL Index is not designed to evaluate the physical function of stroke patients. Special items that are more important for measuring the outcome of stroke are not included in the scale. A standard scale for different diseases remains to be developed. Although the Katz ADL Index has been frequently used for the evaluation of general function in an elderly population, there may be some problems in administration of the item of continence.

**Conclusions**

This study provides general information about the prevalence of stroke and how stroke is related to dementia and disability in a community-based population aged ≥75 years. The prevalence of stroke was 10.0% in men and 8.0% in women. More than half of the stroke patients had a specific disability in ADL. Dementia appeared among one third of stroke survivors. Stroke may account for 18% of the prevalence of dementia, although the link between stroke and dementia may not always be causative. Together with dementia and hip fracture, stroke is a major contributor to disability in most aspects of ADL in very old people.

**Acknowledgments**

This study was financially supported by the Swedish Medical Research Council, the Swedish Council for Social Research, the Swedish Municipal Pension Institute, the Torsten & Ragnar Söderbergs Foundation, the Greta and Johan Mårtensson Foundation, the Grohensky Foundation, the SHMF Foundation, and the Gun and Bertil Stohnes Foundation. We thank all workers of the Kungsholmen Project for data collection and management and Dr. Brent Small for revision of the manuscript.

**References**


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Stroke. 1998;29:2094-2099
doi: 10.1161/01.STR.29.10.2094

Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0039-2499. Online ISSN: 1524-4628

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