Stroke in the Young in the Northern Manhattan Stroke Study

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Background and Purpose—Stroke and stroke subtype incidence in young black and Hispanic populations have not been well studied. The purpose of this study was to determine stroke incidence rates in these populations and to compare rates among various race-ethnic, sex, and age groups.

Methods—A population-based incidence study identified all cases of first stroke in Northern Manhattan from 1993 to 1997. Stroke and stroke subtype incidence rates were calculated for younger (20 to 44 years of age) and older (≥45 years of age) adults. The relative risk (RR) of stroke in blacks and Hispanics compared with whites was calculated. Stroke subtypes, infarct subtypes, and case fatality rates were compared in the young and old and in different race-ethnic groups and sexes.

Results—Over 4 years, 74 cases of first stroke in young patients were discovered (47% women, 12% black, 80% Hispanic, 8% white). The stroke incidence rates (cases per 100 000 persons per year) in the young were 23 overall, 10 for infarct, 7 for intracerebral hemorrhage (ICH), and 6 for subarachnoid hemorrhage. The RR of stroke in the young was greatest for blacks (2.4; 95% CI, 0.8 to 6.7) and Hispanics (2.5; 95% CI, 1.1 to 5.8) compared with whites. ICH was more frequent in men with a RR of 3.7 (95% CI, 1.4 to 10.1). Case fatality rates at 30 days were higher in blacks (38%) and Hispanics (16%) compared with whites (0%).

Conclusions—Young blacks and Hispanics have greater stroke incidences than young whites. **(*Stroke*. 2002;33:2789-2793.)**

Key Words: incidence ■ mortality ■ racial differences ■ stroke ■ young adults

Stroke is a leading cause of morbidity and mortality in industrialized countries. When it occurs in young persons, they may have a longer period of time to live with their disability, and this may contribute to a lifetime of medical complications. The lost productivity of a young working person may account for costs associated with stroke exceeding the costs of stroke in an older person.

Many studies have examined the incidence of stroke in the young. However, only recent studies using CT have accurately identified the incidence of the major subtypes of stroke (cerebral infarction, intracerebral hemorrhage [ICH], and subarachnoid hemorrhage [SAH]).[1–10] This subtyping is clearly important because the different subtypes may have different risk factors and pathogeneses.

Several studies have shown differences in stroke incidence among whites, blacks, and Hispanics,[11–13] but only 1 study has investigated differences in incidence in the young. Kittner et al[10] described differences in stroke rates in a young white and black population and showed that young blacks have a higher incidence than whites. To the best of our knowledge, no other studies have compared stroke incidence among young blacks, Hispanics, and whites living in the same community.

Subjects and Methods

The Northern Manhattan Stroke Study (NOMASS) is an ongoing, prospective, population-based study designed to determine stroke incidence, risk factors, and outcomes in a multiethnic urban population. For the stroke incidence study, all hospitalized and nonhospitalized strokes were surveyed in Northern Manhattan within the 10032, 10033, 10034, and 10040 zip codes. In 1990, this population consisted of ≈210 000 residents.

Patients were enrolled in the incidence study if they (1) were diagnosed with a first stroke between July 1, 1993, and June 30, 1997; (2) had resided in Northern Manhattan for at least 3 months; and (3) were at least 20 years of age. Patients with transient ischemic attacks (ie, neurological deficits lasting <24 hours and no acute stroke evident by neuroimaging) were excluded. All potential cases were discussed with a study neurologist to confirm eligibility. These surveillance programs have previously been described in detail,[11] but the following summarizes the methods used.

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Patients were ascertained through surveillance programs at Columbia Presbyterian Medical Center, where most persons with stroke were hospitalized, and at 14 hospitals outside the immediate region. At Columbia Presbyterian Medical Center, daily lists of all admissions and discharges and logs of CT studies were reviewed. Patients with a diagnosis of stroke, cerebrovascular accident, SAH, ICH, and transient ischemic attack were screened. In addition, patients with aphasia, hemiparesis, weakness, coma, syncope, change in mental status, carotid artery stenosis, headache, seizure, loss of consciousness, weakness, dizziness, or vertigo were screened. Screening of the cases involved medical record review in all cases. Telephone contact with the treating physician or patient interviews were also used. Information on patients with a clinical diagnosis of stroke and found dead on arrival was obtained from the Emergency Department and from the Medical Examiner's office in the New York City Department of Health.

Monthly discharge lists from the 14 hospitals outside the immediate region were reviewed for residents of Northern Manhattan with a primary, secondary, or tertiary diagnosis of stroke (*International Classification of Diseases*, ninth revision, codes 430 through 438, 446, and 447). NOMASS project staff reviewed and abstracted these medical records, and eligible patients were invited for in-person enrollment. A survey of the New York City Department of Health and Coroner's Office death certificate data were also reviewed to identify nonhospitalized sudden, fatal stroke.

In addition, community-based surveillance systems were used to detect nonhospitalized strokes. Local physicians were surveyed, and stroke referrals to Visiting Nurses' Services were reviewed. Random-digit dialing was also used to ascertain incident strokes. Audits and Surveys, Inc (Langhorne, Pennsylvania), a survey research firm, conducted interviews in English or Spanish to determine stroke status. Both published and unpublished telephone numbers were randomly generated with dual-frame sampling. Those subjects who positively responded when asked whether they had a stroke were referred to the study for validation of the diagnosis. Finally, direct community outreach strategies were used to encourage self-referral of stroke patients not previously identified.

All patients ascertained by the above methods were screened for eligibility by a project neurologist and were counted in the incidence data. To ensure that no patient was enrolled twice, all cases were cross-checked according to the patient's medical record number, Social Security number, birth date, and name.

Sociodemographic data, including age, sex, and race-ethnicity, were recorded. When the patient was unable to answer questions, a member of the family or caregiver (proxy) who was knowledgeable about the patient's history was interviewed. Race-ethnicity was based on self-identification through a series of interview questions modeled after the US census and conforming to the standard definitions outlined by Directive 15.[14] These governmental directives have been mandated for all epidemiological research funded by the National Institutes of Health. Two questions were asked: (1) Are you of Hispanic/Spanish origin (no/yes), and (2) which of the following best describes your race: white, black or African American, Eskimo or Aleutian (Alaskan native), Asian or Pacific Islander, or other (specify)? All participants identifying themselves as Hispanic were classified as such regardless of the answer to question 2. The Hispanic population enrolled in NOMASS is representative of the Caribbean Hispanic community in New York City.

Chart review was used to determine patients' medical and neurological histories, findings from general and neurological examinations, and laboratory studies, including CT or MRI, neurovascular Doppler ultrasonographs, ECGs, echocardiographies, and blood tests. These were used to classify stroke as cerebral infarction (and infarct subtypes), ICH, or SAH. Patients with cerebral infarction had evidence of focal neurological symptoms or signs and brain imaging consistent with infarction. Infarct subtypes were classified as lacunar, extracranial atherosclerosis, intracranial atherosclerosis, cardioembolic, associated with other causes, associated with conflicting mechanisms, or cryptogenic. Lacunar infarcts showed brain imaging evidence of a small, deep infarct or a normal repeated brain image, normal or minimal large-artery stenosis, and no source of cardioembolism. Infarcts related to extracranial atherosclerosis required carotid or vertebral artery occlusion or moderate to severe stenosis (>60%) correlating with the territory of infarction. Infarcts related to intracranial atherosclerosis required intracranial large-artery stenosis or occlusion (by cerebral angiography, MR angiography, or transcranial Doppler studies) correlating with the territory of infarction. Cardioembolic infarcts required documentation of atrial fibrillation or flutter, valvular heart disease, cardiac intraluminal thrombus, cardiomyopathy, recent (<6 months) myocardial infarction, bacterial or marantic endocarditis, atrial myxoma, or pulmonary vein thrombosis. Infarcts associated with other causes included dissection, fibromuscular dysplasia, vasculitis, sickle cell anemia, stroke in the setting of migraine, and other diagnosed but rare or unusual etiologies. Infarcts with a conflicting mechanism met criteria for >1 of the above definitions. Cryptogenic infarcts did not meet criteria for infarcts of determined cause or may have had inadequate evaluation that makes diagnostic classification difficult.

TABLE 1. Demographics of Stroke Patients in Northern Manhattan in Young and Older Age Groups

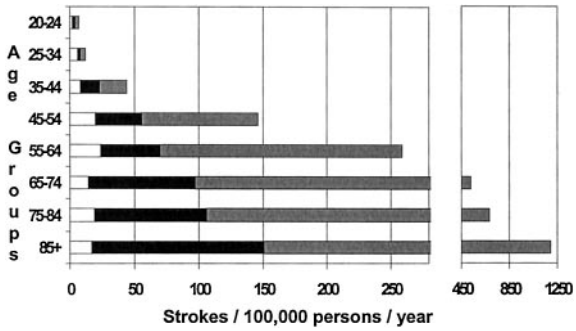
	Age 20 to 45 Years	Age ≥45 Years
Mean (SD) age in years	37 (6)	71 (13)
Total patients, n	74	850
Women, n (%)	35 (47)	486 (57)
Race-ethnicity, n (%)		
White	6 (8)	238 (28)
Black	9 (12)	195 (23)
Hispanic	59 (80)	417 (49)

Patients with ICH had evidence of focal neurological symptoms or signs and brain imaging evidence of intraparenchymal hemorrhage. Secondary causes of hemorrhage such as association with blood dyscrasia or anticoagulant use, arteriovenous malformation, or cavernous angioma were included, but hemorrhage from trauma or tumor was excluded. Patients with SAH had sudden onset of neurological deficits, headache, neck stiffness, or loss of consciousness with evidence of subarachnoid blood on imaging or xanthochromia or red blood cells in cerebrospinal fluid on lumbar puncture. Patients with traumatic SAH were excluded.

In blacks, Hispanics, and whites, average annual age-specific incidence rates for stroke and stroke subtypes were calculated from the number of first stroke patients within each age group in Northern Manhattan and dividing by the Northern Manhattan population within each age group (as ascertained by the 1990 US Census[15]). The "young" age group was defined as those between 20 and 45 years of age; the "older" age group, those ≥45 years. Age-adjusted, race-ethnic–specific, and sex-specific stroke incidence rates were calculated in the young and older age groups. Frequency rates of infarct subtypes were compared between the young and older patients. Using stroke subtype–specific, age-adjusted incidence rates of the various race-ethnic and sex groups, we calculated relative risks of stroke using whites and women as reference groups. Confidence intervals (95% CIs) of estimates for log relative rates were obtained by use of the delta method, which is used to calculate the variance of a differentiable function of an estimator.[16] Race-ethnic–specific and sex-specific 30-day case fatality rates were calculated for stroke and stroke subtypes.

Results

Over 4 years, 924 stroke cases were enrolled in the incidence study. The 74 cases of young stroke were more frequently male and more commonly Hispanic compared with the older cases (Table 1). The overall incidence of stroke in the young was 23 per 100 000 persons per year, and the age-specific incidences of stroke and stroke subtypes are shown in the Figure. With increasing age, the incidence of SAH remained



Incidence of infarct (gray bar), ICH (black bar), and SAH (white bar) in Northern Manhattan.

relatively steady, the ICH incidence increased gradually, and the infarct incidence increased dramatically. Of all strokes in the young, 45% were infarct, 31% were ICH, and 24% were SAH. By comparison, of all strokes in the older group, 80% were infarct, 15% were ICH, and 5% were SAH. The infarct subtype diagnoses included extracranial atherosclerosis (2 [6%] in young versus 45 [7%] in older), intracranial atherosclerosis (3 [9%] in young versus 41 [6%] in older), lacunar (6 [18%] in young versus 124 [19%] in older), cardioembolic (2 [6%] in young versus 140 [22%] in older), conflicting mechanism (0 in young versus 19 [3%] in older), cryptogenic (18 [55%] in young versus 267 [42%] in older), and other causes (2 [6%] in young versus 4 [0.6%] in older).

The stroke subtype incidence of different race-ethnic groups and sexes for those 20 to 44 years of age are shown in Table 2. The age-adjusted relative risks of stroke comparing blacks and Hispanics with whites and comparing men with women are shown in Table 3. In the young, the relative risk of any stroke was greater in blacks and significantly greater in Hispanics. The risk of ICH was greater in men than in women, but there were no significant sex differences in risk of infarct or SAH.

Case fatality rates at 30 days are shown in Table 4. In the young, ICH had the greatest case fatality rate, followed by SAH. Infarct had a relatively lower case fatality rate. Blacks had a greater overall case fatality rate than Hispanics, who had a higher rate than whites. This pattern was strongest in the infarct and ICH subtypes. Men had a greater overall case fatality rate (21%) than women (11%).

TABLE 2. Age-Adjusted Stroke Incidence Rates (Cases/100 000 Persons/Year) and Percentages of Stroke Subtypes in Persons Aged 20 to 44 Years Old in Northern Manhattan

Study	All Stroke	Infarct, %	ICH, %	SAH, %
Northern Manhattan	23	10 (45%)	7 (30%)	6 (26%)
Blacks	25	11	8	6
Hispanics	26	11	8	6
Whites	10	7	0	3
Women	21	11	3	7
Men	25	9	11	4

TABLE 3. Age-Adjusted Relative Risks (and 95% CIs) of Stroke in Blacks and Hispanics Compared With Whites and in Men Compared With Women in Northern Manhattan Among Persons Aged 20 to 44 Years

	Black vs White	Hispanic vs White	Men vs Women
Any Stroke	2.4 (0.8–6.7)	2.5 (1.1–5.8)	1.2 (0.8–1.9)
Infarct	1.5 (0.4–6.1)	1.5 (0.5–4.5)	0.9 (0.5–1.8)
ICH	*	*	3.7 (1.4–10.1)
SAH	1.7 (0.2–12.4)	2.0 (0.5–8.6)	0.6 (0.2–1.6)

*Unable to calculate because no ICH occurred in young whites.

Discussion

The overall stroke incidence among those <45 years of age in Northern Manhattan is greater than in several other studies that also used CT for stroke diagnosis (Tables 2 and 5). The particularly high incidence in blacks and Hispanics appears to contribute to this difference. The greater incidence is consistent among other black populations. South African blacks had a relatively higher stroke incidence compared with other young populations.[9] Libya, with a mixed population descended from Arabs, black Africans, Turks, Greeks, and Italians, is another population with a high stroke incidence rate.[6] To the best of our knowledge, this is the first study that demonstrates a similarly greater incidence among young Hispanics.

Infarct and ICH incidence was greater among young blacks compared with whites in both Baltimore[10] and Northern Manhattan. In Baltimore, the sex-adjusted odds of cerebral infarction in blacks relative to whites was 2.1 compared with 1.5 (not sex adjusted) in this study. In Baltimore, the odds of ICH in blacks compared with whites was 3.1. Although we could not compute a relative risk for ICH in blacks or Hispanics compared with whites because no young whites in this study during this period had an ICH, blacks and Hispanics clearly had a greater ICH incidence than whites. In Northern Manhattan, as in Baltimore, men had a significantly increased relative risk of ICH compared with women. The incidence of SAH was similar among the various populations presented in Tables 2 and 5. In Northern Manhattan, SAH was more frequent among blacks and Hispanics, but this was not significantly greater than in whites.

In Northern Manhattan, the overall stroke incidence increased with age, but this was related primarily to the increasing incidence of infarcts and, less so, ICH (the Figure). By comparison, SAH showed minimally increased incidence

TABLE 4. One-Month-Case Fatality Rates [n (%)] of Stroke Patients in Northern Manhattan

Study Population	All Stroke	Infarct	ICH	SAH
All patients ≥45 years	129 (16)	72 (11)	43 (34)	14 (38)
All patients <45 years	12 (17)	2 (6)	8 (36)	2 (12)
Black	3 (33)	1 (25)	2 (67)	0
Hispanic	9 (15)	1 (4)	6 (32)	2 (13)
White	0	0	0	0
Women	4 (11)	1 (6)	2 (40)	1 (9)
Men	8 (21)	1 (7)	6 (35)	1 (17)

TABLE 5. Stroke Incidence Rates (Cases/100 000 Persons/Year) and Percentages of Stroke Subtypes in Previous Studies of Stroke in the Young

Study	Age Group, y	All Stroke	Infarct, %	ICH, %	SAH, %
Kuwait[1]	0–39	2.74	...	...	...
	40–49	46.6	...	...	...
Northern Italy[2]	15–44	13.6	8	2.8	2.8
Northern Sweden[3]	18–44	...	11.3	...	...
Cantabria, Spain[4]	11–50	13.9	(46.9%)	(27%)	(25%)
Florence, Italy[5]	15–44	8.8	3.4	1.9	3.2
			(38%)	(21%)	(36%)
Benghazi, Libya[6]	15–40	47	36.4	5.8	4.8
			(78%)	(13%)	(9.5%)
Israel[7]	17–49	10.4	(81%)	(10%)	(8%)
Atlanta blacks[8]	15–44	...	(51%)	(31%)	(17%)
South African blacks[9]	20–54	33	(66%)	(33%)	...
Baltimore[10]	15–44	...	...	...	...
Black men		...	23	14	...
White men		...	10	5	...
Black women		...	21	5	...
White women		...	11	2	...

with age. Among those <45 years of age, the relative incidence rate ratio of hemorrhagic strokes to infarcts was greater than among older adults. These trends suggest that increasing age (or risk factors associated with increasing age) increases the likelihood of infarct more than ICH and the likelihood of ICH more than SAH.

In young Northern Manhattan stroke patients, cryptogenic and "other causes" of infarct were most common (61%), and cardioembolic infarcts were among the least common (6%). Some of the cryptogenic infarcts in this study may have been related to hypercoagulability or inflammatory illnesses. However, sufficient data were not available to accurately remark on the prevalence of such diagnoses.

The infarct subtypes found in this study are comparable to those found in a case series in Iowa in which 65% of infarcts in the young were in either the "undetermined" or "other" categories and 18% were in the "cardioembolic" category as defined by TOAST criteria.[17] Other studies have shown cardioembolic sources in the young in 20% to 33% of infarcts.[3,5,6,8,18] More comparable to Northern Manhattan, only 14% of infarcts in young South African blacks were classified as embolic,[9] and 20% of infarcts in Atlanta blacks were classified as cardioembolic.[8] With the constantly evolving definition of cardioembolic source, the true frequency of this as a cause of stroke in the young is difficult to establish from the above studies. To facilitate the comparison of these statistics, future studies should use a more precise definition of "definite" cardioembolism (such as with atrial fibrillation or prosthetic valves) in addition to a broader definition of cardioembolism encompassing less certain cardioembolic sources.

Northern Manhattan has a similar overall 30-day case fatality rate compared with prior studies that have ranged from a low of 10% in Israel to 34% among South African blacks (Tables 4 and 6). Particularly impressive is the higher fatality rate in blacks (33%) and the lower rate in whites (0%). Blacks in Northern Manhattan have considerably greater rates for both infarct and ICH that are most comparable to those seen in South African blacks.[9] Atlanta blacks also had a higher-than-typical fatality rate for infarction.[8] For SAH, Northern Italians[2] and Finns[19] had the highest fatality rates. Case fatality rates in Northern Manhattan for patients with infarcts and SAH were higher in the older patients than in the younger patients but similar in young and older patients with ICH. Possible explanations for the different fatality rates in these populations could be the diversity of stroke type and severity, variations in frequencies of other diseases that are associated with stroke, differences in stroke evaluation and treatment, or unique response to stroke therapies. Adequate data were not available in this study to determine whether variations in treatments may have been responsible for variations in case fatality rates.

TABLE 6. One-Month-Case Fatality Rates [n (%)] in Previous Studies of Stroke in the Young

Study Population	All Stroke	Infarct	ICH	SAH
Iowa[18]		14 (7)		
Northern Italy[2]	5 (17)	0	2 (33)	3 (50)
Northern Sweden[3]		5 (6)		
Cantabria, Spain[4]	18 (22)	3 (8)	10 (45)	5 (25)
Benghazi, Libya[20]	(12.7)			
Finland[19]				47 (43)
Florence, Italy[5]	(23)	(6)	(50)	(18)
Canada[21] (gender-adjusted)				(14)
Atlanta blacks[8]	50 (23)	(12)	(40)	(26)
South African blacks[9]	(34)	(22)	(58)	
Israel[7]	25 (10)	10 (5)	9 (36)	4 (20)

Variations in stroke incidence among various race-ethnic, sex, and age groups could be related to variations in frequencies of risk factors in these groups. This study describes differences in incidences in the populations studied and was not designed to determine whether specific characteristics (risk factors) of these populations were responsible for differences in stroke incidence. A limitation of this study, as with many studies of young stroke patients, is the small number of young patients. Minor changes in the actual numbers can have effects on calculated incidences, stroke subtype percentages, infarct subtype percentages, and case fatality percentages. This is particularly true when smaller subgroupings such as infarct subtype percentages are compared. Additionally, the Hispanic population described in this study is mainly representative of Caribbean Hispanics. These findings may not necessarily extend to other Hispanic populations. Despite these limitations, we believe these incidence rates help fill gaps in our knowledge of the epidemiology of stroke in young black and Hispanic populations.[20,21]

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