2

Incidence of stroke in the elderly

2.1 Incidence, risk and case fatality of stroke in the elderly

Abstract

Objective - To estimate the incidence, survival and life-time risk of stroke in the elderly.
Methods - We conducted a study in 7,721 participants from the population-based Rotterdam Study who were free from stroke at baseline (1990-1993) and were followed up for stroke until January 1 1999. We calculated age and sex specific incidence, case fatality rates and lifetime risks of stroke.
Results - Mean follow-up was 6.0 years and 432 strokes occurred. The incidence rate of stroke per 1,000 personyears increased with age and ranged from 1.7 (95% CI 0.4-6.6) in men aged 55 to 59 years to 69.8 (95% CI 22.5-216.6) in men aged 95 years or over. Corresponding figures for women were 1.2 (95% CI 0.3-4.7) and 33.1 (9% CI 17.8-61.6). Men and women had similar absolute lifetime risks of stroke (21% for those aged 55 years). The survival after stroke did not differ according to sex.
Conclusions - Stroke incidence increases with age, also in the very old. Although the incidence rate is higher in men than in women over the entire age range, the lifetime risks were similar for both sexes.

INTRODUCTION

In recent decades a decreasing trend in mortality of stroke has been observed.[1-6] Nevertheless, stroke is still a leading cause of death in the western countries and puts a large burden on health care systems.[7,8] Stroke incidence increases with age, but information on the incidence and survival of stroke in the very old in the general population is limited. Since populations are growing older this information is of importance, particularly for health care planners.[9] Also, data on the risk of stroke during one's life is lacking and is of interest on the individual level. We performed a large prospective study on the incidence of stroke in a population-based cohort of elderly subjects aged 55 years or over, which enabled us to calculate incidence rates, survival, case fatality and period and lifetime risks of stroke.

METHODS

Study population

The present study was performed in the framework of the Rotterdam Study, a population-based, single-center cohort study on chronic and disabling diseases in the elderly. All inhabitants of Ommoord, a suburb of Rotterdam, aged 55 years or more were invited. People living in homes for the elderly were included.[10] Participation rate of those invited for the study was 78% and a total of 7,983 subjects participated. The Medical Ethics Committee of Erasmus University approved the study. Written informed consent to retrieve information from treating physicians was obtained from all participants. Baseline measurements were obtained from 1990 to 1993 and consisted of an interview at home and two visits to the research center for physical examination. During the interview a previous stroke was assessed by asking "did you ever suffer from a stroke, diagnosed by a physician?" Medical records of subjects who answered 'yes' were checked and a previous stroke was considered to have occurred if medical records confirmed it.[11] The present study comprises a cohort of 7,721 subjects who were free from stroke at baseline. Follow up for stroke was complete until January 1, 1999.

Assessment of stroke

Once subjects enter the Rotterdam Study they are continuously monitored for major events through automated linkage with files from the general practitioners. For the present study information on stroke and death was used. Stroke is defined as rapidly developing clinical signs of focal or global disturbance of cerebral function with no apparent cause other than a vascular origin. When an event or death had been reported, additional information was obtained by interviewing the general practitioner and by scrutinizing information from hospital discharge records in case of admittance or referral. Information from reports on all possible strokes was reviewed by two research physicians and a neurologist (PJK) who classified the stroke as definite, probable or possible stroke.[12] The stroke was definite if the diagnosis was based on typical clinical symptoms and neuro-imaging excluded other diagnoses. The stroke was considered probable in case typical clinical symptoms were present but neuro-imaging was not performed. For fatal strokes, other causes of death, especially cardiac should have been excluded. A stroke was classified as possible if clinical symptoms were less typical and neuro-imaging was not performed, or if a cardiac cause of death could not be excluded in case of a fatal stroke. All reported transient ischemic attacks also were reviewed in order to screen and classify all strokes. Subarachnoid hemorrhages were excluded. Until the end of follow up 202 definite, 130 probable and 96 possible strokes occurred. We used definite and probable strokes in the analyses (n=432). For subjects with a stroke, follow-up was complete until January 1, 1999. Case fatality within 28 days was defined as death occurring within 28 days after onset of the stroke.

Subtypes of stroke

If the CT or MRI scan showed a cerebral hemorrhage or infarction the type of stroke was coded accordingly. In case of no abnormality on CT or MRI, the stroke was classified as cerebral infarction. Strokes without neuro-imaging could be classified as possible hemorrhagic stroke or a cerebral infarction on the basis of the following symptoms. A possible hemorrhagic stroke was coded in case of sudden hemiplegia or other focal signs with permanent unconsciousness or death within hours. The stroke was classified as possible cerebral infarction if there was limited impairment (isolated aphasia, isolated weakness of one limb,

isolated facial weakness or isolated hemianopia), complete improvement within 72 hours or documented atrial fibrillation at time of the stroke.

Data analysis

The age-specific incidence rate was obtained for each 5-year band by dividing the number of strokes by the total amount of person-years attributed to a specific age category. The follow-up ended either at occurrence of stroke, or at death, or at January 1, 1999, whichever came first. Participants who suffered from a subarachnoid hemorrhage were censored on the date of the event. Incidence rates are given with 95% confidence intervals (CI), assuming Poisson distribution. We calculated incidence and 28 days case fatality rates for subtypes of stroke in 10-years age strata. For the calculation of 52 weeks case fatality rates we restricted ourselves to cases that occurred before December 31, 1998. We used Cox proportional hazards regression to investigate gender differences in risk of stroke and survival after stroke. In these analyses we adjusted for age at baseline and stroke, respectively. Survival after stroke was calculated using the Kaplan Meier method. In order to calculate the absolute risk of stroke over time we took the competing risk of dying into account. First we obtained the stroke free survival at different ages from the cohort with the Kaplan Meier method. Age at baseline was used as entry time and age at end of follow-up, occurrence of stroke or death as failure time. Then the cumulative absolute risk of stroke over a period was calculated as the integrated product of the age-specific stroke incidences and the stroke-free survival.[13] The risk of stroke over time was calculated separately for men and women at ages 55, 65, 75 and 85 years.

RESULTS

The mean follow-up time was 6.0 years. We had 46,011 person-years of observation and 432 suffered from a first-ever stroke. Of these 39 were primary intracerebral hemorrhages (9.0%), 233 cerebral infarctions (53.9%) and 160 unspecified strokes (37.0%). A CT or MRI scan was performed in 256 (59.3%) cases and in 2 cases necropsy was performed. The hemorrhages and infarctions were confirmed by neuro-imaging in 74.4% and respectively 94.4%. A total of 256 persons (59.3%) were hospitalized.

Table 1

Age and gender specific incidence rate of stroke in the elderly.

Age	Men				Women				Total			
	No. of strokes	Person-years	Incidence rate*	95% CI	No. of strokes	Person-years	Incidence rate*	95% CI	No. of strokes	Person-years	Incidence rate*	95% CI
55-59	2	1205.1	1.7	0.4-6.6	2	1691.2	1.2	0.3-4.7	4	2896.3	1.4	0.5-3.7
60-64	8	3428.6	2.3	1.2-4.7	10	4725.0	2.1	1.1-3.9	18	8153.6	2.2	1.4-3.5
65-69	31	4067.9	7.6	5.4-10.8	16	5230.4	3.1	1.9-5.0	47	9298.3	5.1	3.8-6.7
70-74	32	3565.5	9.0	6.3-12.7	29	5072.1	5.7	4.0-8.2	61	8637.7	7.1	5.5-9.1
75-79	48	2656.9	18.1	13.6-24.0	65	4557.0	14.3	11.1-18.1	113	7213.9	15.7	13.0-18.8
80-84	31	1556.9	19.9	14.0-28.3	41	3495.0	11.7	8.6-15.9	72	5051.8	14.3	11.3-18.0
85-89	17	665.6	25.5	15.9-41.1	49	2379.5	20.6	15.6-27.2	66	3045.0	21.7	17.0-27.6
90-94	8	239.6	33.4	16.7-66.8	30	1130.3	26.5	18.6-38.0	38	1369.9	27.7	20.2-38.1
95+	3	43.0	69.8	22.5-216.6	10	301.7	33.1	17.8-61.6	13	344.7	37.7	21.9-65.0
All	180	17429.0	10.3	8.9-12.0	252	28582.2	8.8	7.8-10.0	432	46011.2	9.4	8.5-10.3

* Rate per 1000 person-years.

The incidence rate of stroke increased with age and ranged from 1.7 (95% CI 0.4-6.6) in men aged 55-59 years to 69.8 (95% CI 22.5-216.6) in men aged 95 or over (table 1). Corresponding rates for women were 1.2 (95% CI 0.3-4.7) and 33.1 (95% CI 17.8-61.6), respectively. Incidence rates were higher in men than in women over the entire age range. Adjusted for age at baseline the relative risks of stroke for men compared to women in partipants aged younger and older than 75 years were respectively 1.64 (95% CI 1.26-2.15) and 1.36 (95% CI 1.02-1.83).

Table 2

Incidence rate of subtypes of stroke.

Age	Cerebral infarction			Intracerebral hemorrhage			Unspecified stroke		
	No. of cases	IR*	95% CI†	No. of cases	IR*	95% CI†	No. of cases	IR*	95% CI†
55-64	17	1.5	1.0-2.5	2	0.2	0.0-0.7	3	0.3	0.1-0.8
65-74	72	4.0	3.2-5.1	10	0.6	0.3-1.0	26	1.4	1.0-2.1
75-84	111	9.0	7.5-10.9	22	1.8	1.2-2.7	52	4.2	3.2-5.6
85+	33	6.9	4.9-9.8	5	1.1	0.4-2.5	79	16.6	13.3-20.7
All	233	5.1	4.5-5.8	39	0.8	0.6-1.2	160	3.5	3.0-4.1

* IR: Incidence rate per 1000 person-years.
† CI: Confidence interval.

Table 2 shows that the incidence rate increased with age until the age of 85 for all subtypes of stroke. After age 85, the proportion of unspecified strokes became very high and estimates of the frequency of subtypes of stroke less reliable. The proportion of hospitalized strokes decreased with age in both sexes (Figure 1).

Figure 1

Incidence rate per 1000 person-years for stroke and hospitalized stroke in relation to age in men and in women.

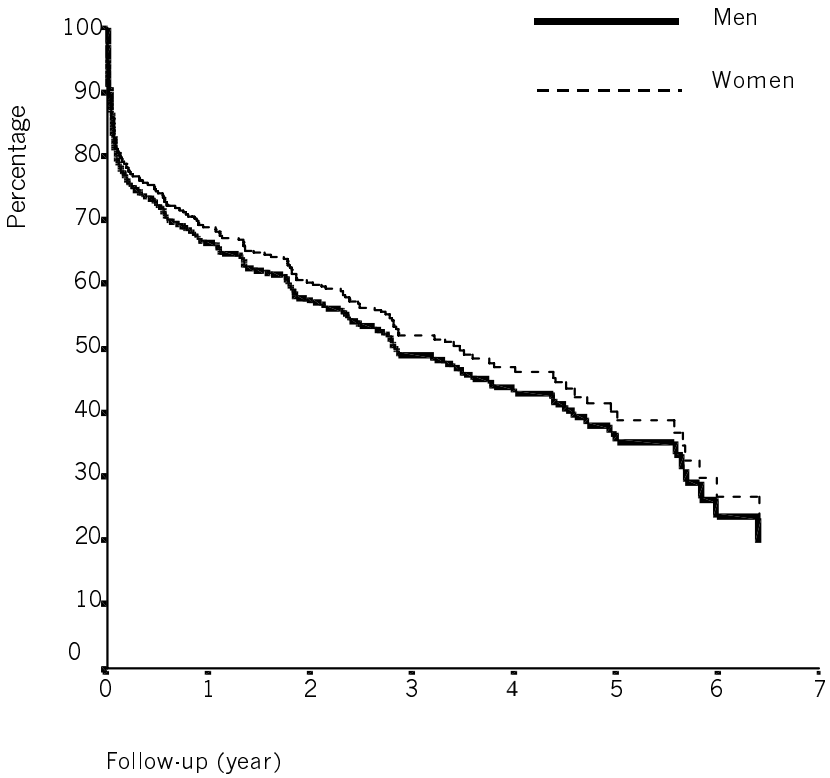

Figure 2

Cumulative survival after stroke according to gender, adjusted for age at stroke.

Case fatality

The overall 28-days case fatality rate was 32.5% for all strokes, 12.4% for cerebral infarctions and 33.3% for cerebral hemorrhages. Corresponding 52-weeks case fatality rates were 40.4, 23.6 and 62.9%. We observed no difference in survival after stroke between men and women (figure 2). Case fatality rates of stroke, cerebral infarction and intracerebral hemorrhage increased with age (table 3).

Table 3

28-Days case-fatality for stroke, subtypes of stroke and hospitalized strokes.

Age	Stroke		Cerebral infarction		Intracerebral hemorrhage		Hospitalized stroke	
	Number/ total	% fatal	Number/ total	% fatal	Number/ total	% fatal	Number/ total	% fatal
55-64	2/22	9.0	0/17	0.0	1/2	50.0	2/16	12.5
65-74	15/108	13.9	5/72	6.9	1/10	10.0	12/76	15.8
75-84	33/105	31.4	15/111	13.5	8/22	36.4	27/119	22.7
85+	61/117	52.1	9/33	27.2	3/5	60.0	22/45	48.9
All	111/342	32.5	29/233	12.4	13/39	33.3	63/256	24.6

Lifetime risk of stroke

Figure 3 shows survival and stroke-free survival for 55 and 75 years old participants as observed in the total study cohort. The areas between the survival and stroke free survival curves represent the average time subjects live after a stroke. The area comprised 3.45 (95% CI 2.93-3.97) years for men and 3.12 (95% CI 2.69-3.55) years for women aged 55 years. Corresponding figures for persons aged 75 years were 2.16 (95% CI 1.59-2.73) and 2.10 (95% CI 1.63-2.57) years, respectively. Table 4 shows the cumulative incidence of stroke over time for men and women at different ages. The absolute risk of getting a stroke is nearly similar for men and women in all age categories, reflecting higher incidence rates, but shorter life expectancy in men as compared to women.

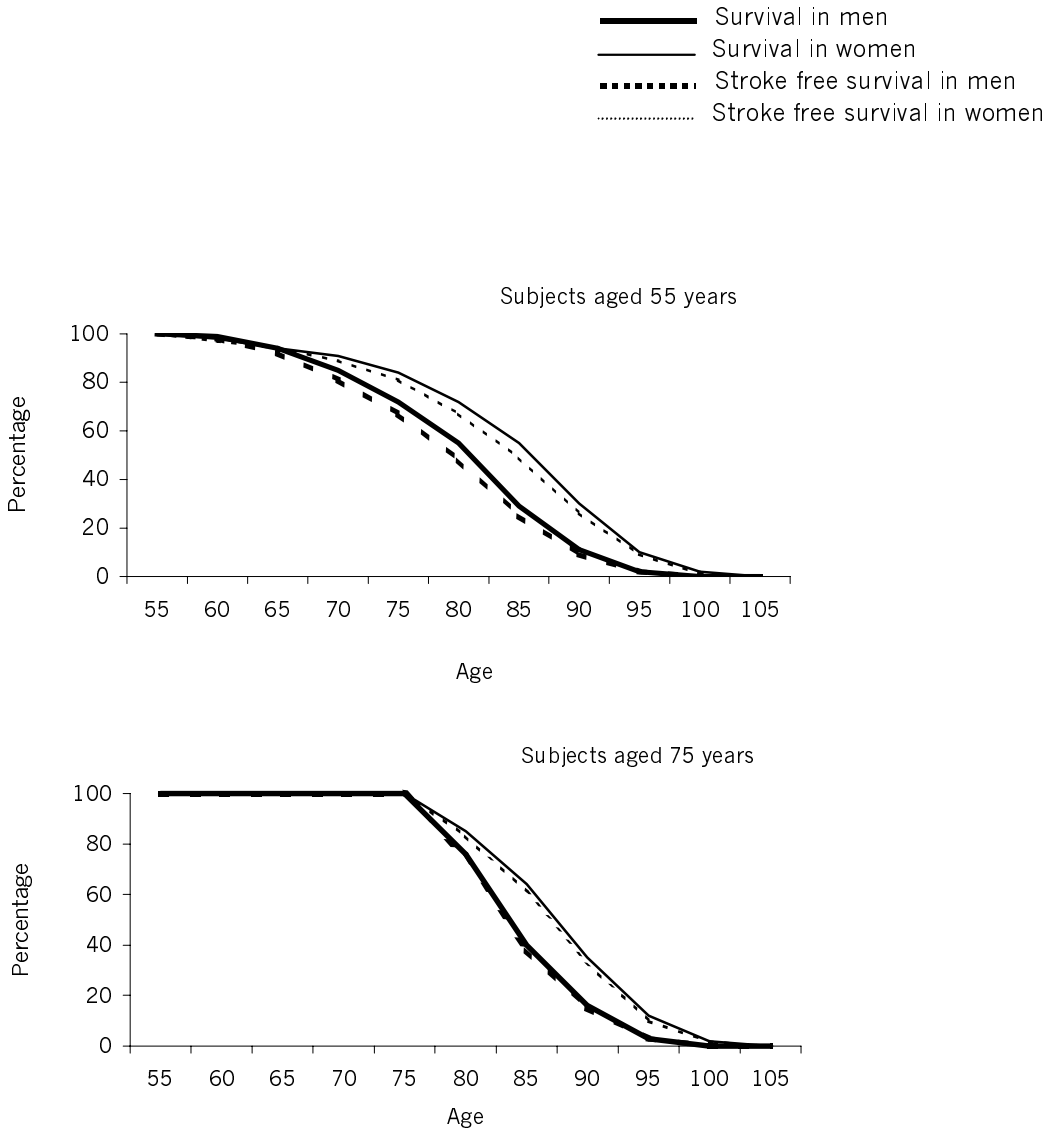

Figure 3
Survival and stroke-free survival according to age and gender.

Table 4

Period and lifetime risk of stroke for 55, 65, 75 and 85 years old men and women taking competing risk of death into account.

Age	Period risk (%)								Lifetime risk
	5yr	10yr	15 yr	20 yr	25 yr	30 yr	35 yr	40 yr	
Men									
55	0.7	1.8	4.8	8.5	13.7	17.3	19.3	20.2	20.5
65	2.2	6.0	11.8	15.9	18.2	19.1	19.4		19.4
75	6.9	12.5	15.7	17.0	17.4				17.4
85	6.0	8.3	9.0						9.0
Women									
55	0.6	1.7	2.9	5.6	10.7	14.2	18.1	20.3	21.0
65	1.1	3.9	9.4	13.1	17.2	19.6	20.3	20.4	20.4
75	5.3	9.6	14.4	17.1	17.9	18.0	18.0		18.0
85	6.8	11.1	12.4	12.6					12.6

DISCUSSION

We found that the incidence rate of stroke was higher in men than in women over the entire age range. Nevertheless, as a net result of a shorter life expectancy and a higher incidence rate of stroke in men as compared to women, lifetime risks of stroke in men and women were similar at different ages.

Case ascertainment

Studies on incidence of stroke are vulnerable to selection bias. Although our participation rate was high (78%), it is conceivable that non-participants had a higher risk profile for stroke. Consequently, our incidence figures most likely are conservative estimates of the true population incidence of stroke. Complete and accurate case ascertainment is crucial for the validity of the results of an incidence study. The prospective study design, standard definitions, defined study population and multiple methods of case finding were in accordance with core criteria proposed by Malmgren and colleagues.[14] Furthermore, the work-up and characteristics of stroke in the present study fulfill criteria for optimal case ascertainment defined by researchers from the WHO MONICA stroke study.[15] The follow-up was complete for all participants and we used extensive and

overlapping case finding methods to reduce selection bias in follow-up. The proportion of non-hospitalized strokes in our study was 39%. This is in accordance with the proportion (46%) found by the Oxfordshire Stroke Project.[16] Rotterdam with nearly 700,000 inhabitants did not have a specific stroke admission strategy during the study period. The low admission rate was mainly explained by a shortage of hospital beds and by the fact that Stroke Units and Stroke Services were not yet widespread available and thrombolytic therapy not yet an established treatment. A weakness of our study that results from the fact that not all strokes were hospitalized is the relatively low proportion of CT or MRI-confirmed strokes. We observed that the proportion of unspecified strokes increased with age. Restriction to only neuro-imaging confirmed strokes would have led to an underestimation of the incidence, especially in the very old. Since only 75% of the intracerebral hemorrhages were confirmed by CT or MRI, the overall results on hemorrhages should be regarded carefully. Almost 95% of the cerebral infarctions were CT confirmed. Therefore, we feel that the overall figures on cerebral infarctions are reliable. However, incidence figures of stroke subtypes in the very old are less reliable.

Stroke incidence studies

One hospital-based study in the Netherlands (1978-1980) reported comparable, though slightly higher incidence rates of stroke than the present study, but did not analyze the very old.[17] Possibly the incidence has declined during the time interval between both studies. The incidence rates found in our study are in accordance with the results from other studies in Europe, although some studies reported lower incidence rates in subjects >85 years.[16,18-24] Studies in Eastern Europe reported higher incidence rates in subjects younger than 85 years, and lower rates in subjects older than 85.[25-28] Incidence rates in Eastern European countries are known to be higher than in Western Europe. The lower rates in the very old in other studies might be explained by under-report of stroke in the elderly, as we have shown that the proportion of hospitalized strokes declines with age. Incidence rates of stroke in subjects with a European background in Auckland, New Zealand (1992) were higher than in the Rotterdam Study.[29] However, the North East Melbourne Stroke Incidence Study (1996-1997) reported similar rates.[30] In our study the survival after stroke was equal in men and women. Most other studies did not find gender differences either.[29,31-34] We observed an increasing case fatality with age, and a higher case fatality of

cerebral hemorrhages as compared to cerebral infarctions. These results are in accordance with results from other studies.[21,29,33,35,36]

Lifetime risk of stroke

Our calculations of lifetime risks of stroke were based on the assumption that characteristics of the cohort remain constant over time. They showed that although the incidence rate of stroke in men was higher than in women, the lifetime risk to get a stroke was similar when we took the competing risk of dying into account. The higher incidence rate of stroke is counterbalanced by shorter survival in men as compared to women. As a consequence, women on average are older when they get a stroke. In conclusion, stroke incidence increases with age, also in the very old. Although incidence rates in men were higher than in women over the entire age range, lifetime risks were similar.

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