Hospital Admissions for Stroke among the Very Old in the USA

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Key Words

Brain ischemia · Brain infarction · Aged, 80 and over

Abstract

Background: We sought to describe the proportion of acute ischemic stroke admissions for very old patients (≥ 85 years), compare the characteristics of very old versus younger patients and identify factors among very old patients associated with adverse outcomes. **Methods:** The 2000 Healthcare Cost and Utilization Project data included acute ischemic stroke hospitalizations for patients ≥ 45 years. The combined outcome was in-hospital mortality or discharge to a long-term care facility. **Results:** Among 15,020 stroke hospitalizations, 20.4% were for very old patients. The outcome rate was higher in hospitalizations for very old patients (2,176/3,058, 71.2%; versus 5,748/11,962, 48%; $p < 0.0001$). More hospitalizations for very old patients were for women (73.5 versus 55.1%; $p < 0.0001$), fewer for Blacks (6.1 versus 12.3%; $p < 0.0001$) and fewer at teaching hospitals (30.4 versus 36.2%; $p < 0.0001$). Among very old patients, factors that were independently associated with the outcome included: age [years; adjusted OR = 1.02 (95% CI = 1.000–1.05)], female gender [1.4 (1.18–1.68)], atrial fibrillation [1.37 (1.15–1.63)], acute myocardial infarction [1.68 (1.20–2.35)], respiratory

failure [3.59 (1.60–8.05)] and teaching hospital admission [0.82 (0.69–0.98)]. Similar results were observed in the hospitalizations for younger patients. The adjusted OR for the outcome displayed geographic disparities in both age groups, but the pattern of the geographic variation was not similar between the two age groups. **Conclusions:** The very old constitute a substantial proportion of stroke hospitalizations. Hospitalizations for very old patients are more likely to end in death or discharge to a long-term care facility than hospitalizations for younger patients. The pattern of geographic disparity in poststroke adverse outcomes differs between younger and very old patients.

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Introduction

The incidence of stroke is strongly associated with increasing age [1]. Although the very old (age ≥ 85 years) are the fastest growing segment of our population [1], the epidemiology of ischemic stroke in the very old in the USA has not been well described.

Prior studies of stroke patients across the age spectrum have demonstrated that stroke prevalence and mortality increase with advancing age, as does poststroke dis-

charge to a skilled nursing facility [2–4]. Studies that have focused upon very old patients with stroke are based on data from Europe and the West Indies [5–9]; these investigations suggest that very old stroke patients have higher inpatient mortality rates [6] and longer lengths of stay [6], and they receive less aggressive care than younger patients [7]. To our knowledge, this is the first study to focus upon very old patients with acute ischemic stroke hospitalized at a US medical center.

Our research objectives were to: (1) describe the proportion of acute ischemic stroke admissions that were for very old patients; (2) present the clinical and hospital characteristics of very old patients compared with younger patients who were hospitalized with an acute ischemic stroke; (3) to identify factors associated with mortality and discharge disposition to a skilled nursing facility among very old patients hospitalized for an ischemic stroke, and (4) to compare the factors related to mortality and discharge to a skilled nursing facility among very old versus younger patients.

Methods

We used data from the 2000 Nationwide Inpatient Sample (NIS) of the Healthcare Cost and Utilization Project (HCUP). HCUP is maintained by the Agency for Healthcare Research and Quality and is the largest collection of hospital care data in the USA; including discharge level information from community medical centers [10]. The 2000 NIS comprised a 20% random sample of 994 US hospitals in 28 states consisting of approximately 7.4 million hospital discharges. A 20% sample of the NIS, including 1.49 million discharges, was used in this study. The inpatient stay records consisted of clinical and resource use information obtained from hospital administrative discharge data. The unit of analysis for this study was an individual hospitalization.

Definitions

We dichotomized patient age using age demarcations employed in other studies of very old patents: very old age was defined as ≥ 85 years and younger age as < 85 years [1, 6–8].

HCUP used the American Hospital Association definitions of hospital type including: nonfederal, short-term, general and other specialty hospitals. Specialized hospitals were obstetrics-gynecology, ear-nose-throat, short-term rehabilitation, orthopedic and pediatric facilities. The 2000 NIS covered the following states: Arizona, California, Colorado, Connecticut, Florida, Georgia, Hawaii, Illinois, Iowa, Kansas, Kentucky, Maryland, Massachusetts, Maine, Montana, North Carolina, New Jersey, New York, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Utah, Virginia, Washington, Wisconsin and West Virginia. The hospital regions were then categorized by HCUP as Northeast, South, Midwest or West. Other hospital characteristics included teaching status, urban or rural location and bed size (small, medium and large).

Outcome Measure

The combined outcome measure of in-hospital mortality and discharge to a long-term care facility was used in this study. Death and institutionalization are often combined as a single endpoint as a common and undesirable stroke outcome for patients [11–17].

Stroke Hospitalization Selection

Acute ischemic stroke hospitalizations were defined as those with a principal discharge diagnosis of occlusion of cerebral arteries [International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) code 434] or acute but ill-defined cerebrovascular disease (ICD-9-CM code 436) [18, 19]. We included hospitalizations for patients ≥ 45 years old and with a length of stay of at least 24 h. We excluded hospitalizations for patients transferred from other acute care facilities [20].

Comorbidity and Procedures

Comorbid conditions, identified using ICD-9-CM codes, were: atrial fibrillation, ischemic heart disease, acute myocardial infarction, respiratory failure, hypertension, congestive heart failure, peripheral vascular disease, transient ischemic attack and diabetes mellitus. In addition to these prespecified comorbid conditions, we also evaluated the total number of all diagnoses per hospitalization. ICD-9-CM procedure codes were used to determine the number of procedures for each hospitalization (up to a maximum of 15 procedure codes per hospitalization).

Cost

Cost estimates were made with the cost-to-charge ratios provided by HCUP for the year 2000. These ratios are created using both operating and capital-related costs to help generate accurate inpatient stay costs [21].

Statistical Analyses

Univariate and Bivariate

Descriptive statistics (such as ranges, means with standard deviations and medians with interquartile ranges) were applied to summarize the baseline characteristics. χ^2 tests were used to compare binary and ordinal variables, and Student's *t* tests were employed to compare dimensional variables for the 2 age groups. Statistical significance was accepted when the *p* value was < 0.05 . No imputations were made for missing values.

Multivariable

Restricting our analysis to hospitalizations for very old patients, we developed a multivariable logistic regression model to identify factors associated with the dependent variable (the combined outcome of inpatient mortality and discharge to a long-term care facility). Potential independent variables were identified based on a priori clinical judgment as well as statistical significance from the bivariate analysis ($p < 0.05$). Acute myocardial infarction and respiratory failure were the only 2 variables forced into the model, on the basis of a priori clinical judgment. Using a backward selection process, independent factors were identified with a *p* value of < 0.05 . These independent factors were then evaluated in a full logistic regression model. An event-per-variable ratio of $> 10:1$ was maintained during the multivariable modeling [22, 23]. All computations were made using PC-SAS version 6.12 for Windows (SAS Institute Inc.; Cary, N.C.).

Table 1. Stroke hospitalization frequency

Specific age groups	Stroke hospitalizations (n = 15,020)	Summary age groups	Stroke hospitalizations (n = 15,020)
≥45 to <55 years	1,094 (7.3)	<85 years	11,962 (79.6)
≥55 to <65 years	1,961 (13.1)		
≥65 to <75 years	3,705 (24.7)		
≥75 to <85 years	5,202 (34.6)		
≥85 to <95 years	2,817 (18.7)	≥85 years	3,058 (20.4)
≥95 years	241 (1.6)		

Figures in parentheses are percentages.

Results

Our dataset included 17,706 hospitalizations for acute ischemic stroke during the year 2000; 15,020 hospitalizations met our inclusion criteria, and 3,058/15,020 (20.4%) involved very old patients (table 1).

Comparison of Characteristics among Very Old versus Younger Stroke Patients

Table 2 provides the data for the comparison of characteristics for hospitalizations for very old versus younger patients. A smaller proportion of hospitalizations for very old patients was for Blacks (6.1 vs. 12.3%; $p < 0.0001$) and a greater fraction for women (73.5 vs. 55.1%; $p < 0.0001$). The admission source for stroke hospitalizations was most commonly via the emergency department in both age groups. Older patients were twice as likely to be admitted from long-term care facilities (2.8 vs. 1.4%; $p = 0.0001$), although this source at admission was uncommon even among hospitalizations for the very old. The mean number of diagnoses was higher among hospitalizations for the very old (mean $\pm$ standard deviation: 7.2 ± 2.6 vs. 6.9 ± 2.6 ; $p < 0.0001$). Hospitalizations for the very old included fewer procedures than for the younger patients (0.7 ± 1.4 vs. 1.0 ± 1.7 ; $p < 0.0001$).

A larger proportion of hospitalizations for very old patients, compared with younger ones, occurred at small community medical centers (13.6 vs. 11.9%; $p = 0.01$), rural hospitals (22.4 vs. 17.7%; $p < 0.0001$) and non-southern hospitals (60.2 vs. 55.8%; $p < 0.0001$). A smaller fraction of hospitalizations for very old patients occurred at teaching hospitals (30.4 vs. 36.2%; $p < 0.0001$).

The combined outcome of in-hospital mortality or discharge to a long-term care facility was much higher in the hospitalizations for very old stroke patients (71.2 vs.

48%; $p < 0.0001$). Similarly, the in-hospital mortality was twice as high among hospitalizations for the very old (10.1 vs. 5.3%; $p < 0.0001$). The discharge disposition to a long-term care facility was also more frequent among hospitalizations for the very old (61.1 vs. 42.7%; $p < 0.0001$).

Multivariable Analysis

The multivariable results are presented in table 3. Among hospitalizations for the very old, several factors were independently associated with the combined outcome of mortality or discharge to a long-term care facility including: age, female gender, atrial fibrillation, acute myocardial infarction and respiratory failure. Admission to a teaching hospital was related to a decrease in the combined outcome. Geographic disparities were observed such that hospitalizations in the following states had lower odds of the combined outcome among the very old: Maryland, New York, Texas and Virginia (fig. 1).

The factors that were independently associated with the combined outcome in the very old patients were similarly related to the combined outcome in younger patients with the exception of teaching status. The pattern of geographic disparities differed in the younger patients such that hospitalizations in the following states had lower odds of the combined outcome: Florida, New Jersey, New York, South Carolina and Virginia (fig. 1).

Discussion

Limitations

We used the HCUP dataset because it is a large state-based inpatient database, containing hospitalization data from a representative sample of US community hospitals from all regions of the country. The HCUP data are subject to the limitations, however, specifically the lack of detailed clinical information about individual patients. Therefore, we could not differentiate between patients experiencing their first versus recurrent strokes. The HCUP data also do not contain information about patients' functional status, stroke subtype or stroke severity, items that are known to be associated with the outcomes of mortality and discharge disposition. Because we were not able to include them in our multivariable modeling, the results of the logistic regression should be examined in the context of this limitation. The HCUP data are cross-sectional in nature, limiting any causal inferences that can be made.

Table 2. Comparison of characteristics and outcomes among younger versus very old stroke patients

Characteristic	Age groups		p value
	<85 years (n = 11,962)	≥85 years (n = 3,058)	
Age, years	70.7 ± 10.0	88.9 ± 3.4	–
Female gender	6,597 (55.1)	2,247 (73.5)	<0.0001
Race	2,442 (20.4)	371 (12.1)	<0.0001
White	6,670 (55.8)	1,963 (64.2)	–
Black	1,468 (12.3)	186 (6.1)	–
Hispanic	563 (4.7)	102 (3.3)	–
Asian/Pacific Islander	232 (1.9)	34 (1.1)	–
Native American	22 (0.2)	6 (0.2)	–
Other	157 (1.3)	43 (1.4)	–
Missing	2,850 (23.8)	724 (23.7)	–
Admission source	–	–	<0.0001
Emergency department	9,498 (79.4)	2,387 (78.1)	–
Long-term care facilities	166 (1.4)	87 (2.8)	–
Other	2,298 (19.2)	584 (19.1)	–
Number of diagnoses	6.9 ± 2.6	7.2 ± 2.6	<0.0001
Comorbid conditions	–	–	–
Hypertension	8,323 (69.6)	1,885 (61.6)	<0.0001
Diabetes mellitus	3,924 (32.8)	488 (16.0)	<0.0001
Ischemic heart disease	2,949 (24.7)	767 (25.1)	0.6
Atrial fibrillation	2,148 (18.0)	1,043 (34.1)	<0.0001
Congestive heart failure	1,395 (11.7)	652 (21.3)	<0.0001
Valvular disease	698 (5.8)	245 (8.0)	<0.0001
Peripheral vascular disease	572 (4.8)	164 (5.4)	0.2
Respiratory failure	322 (2.7)	70 (2.3)	0.2
Myocardial infarction	177 (1.5)	62 (2.0)	0.03
Facility characteristics	–	–	–
Small hospital size	1,428 (11.9)	415 (13.6)	0.01
Rural location	2,115 (17.7)	685 (22.4)	<0.0001
Teaching status	4,332 (36.2)	931 (30.4)	<0.0001
Southern region	5,283 (44.2)	1,218 (39.8)	<0.0001
Discharge disposition	–	–	–
Death or long-term care facility	5,748 (48.0)	2,176 (71.2)	<0.0001
Long-term care facility	5,113 (42.7)	1,868 (61.1)	<0.0001
Died in hospital	635 (5.3)	308 (10.1)	<0.0001
Home	6,214 (52.0)	882 (28.8)	<0.0001
Cost, USD	11,351 ± 14,594	10,367 ± 17,323	0.1
Length of stay, days	6.4 ± 7.2	6.7 ± 11.7	0.1
Procedures	1.0 ± 1.7	0.7 ± 1.4	<0.0001

Figures are means ± standard deviation or numbers of subjects with percentages in parentheses.

Also, we used the combined endpoint of in-hospital mortality and discharge to a skilled nursing facility as the outcome in the multivariable modeling. The variables associated with the combined endpoint might not be the same as those for death alone or discharge to a skilled nursing facility alone.

Finally, we used the HCUP dataset, which includes community hospitals, because the majority of ischemic

stroke care in the USA takes place in community hospitals. Future studies should be conducted to determine if similar results are observed at tertiary care centers.

Despite these limitations, we have found that the very old account for 20% of the hospitalizations for ischemic stroke in community medical centers in the USA. This proportion is higher than expected from estimates of the US population who are aged ≥85 years. Specifically, in

Fig. 1. Adjusted geographic variation in in-hospital mortality or discharge to a long-term care facility. The shaded areas represent the states that are independently associated with a *reduced* odds of the combined outcome (in-hospital mortality or discharge to a long-term care facility). **a** Adjusted outcome rates among hospitalizations for very old patients (≥ 85 years). **b** Adjusted outcome rates among hospitalizations for younger patients (< 85 years).

the USA in the year 2000, although 4% of the population ≥ 45 years was aged ≥ 85 years [24], 13% of the community hospitalizations for patients ≥ 45 years were for patients aged ≥ 85 years [10].

Our observed proportion of stroke in the very old is higher than reported rates in the Netherlands (10%) [25], Spain (13.1–16.5%) [26], Denmark (16%) [8], the French West Indies (17%) [7] or Sweden (18.8%) [27] but is lower than that in the European Union (30%) [5]. International differences in hospitalization rates for nonstroke medical and surgical indications have been demonstrated previously [28].

We also found that almost three fourths of the hospitalizations for the very old result in either death or discharge to a long-term care facility after stroke. The previous studies regarding stroke hospitalizations in very old patients do not report data for this combined outcome. Rather, they found rates of death or discharge to a skilled nursing facility ranging from 5 to 70%, depending on stroke subtype, stroke severity, patient characteristics and follow-up period [13, 15–17].

As expected, some comorbid conditions were seen more commonly in very old patients (e.g. atrial fibrillation), and others were more common in younger ones (e.g. diabetes). These results were similar to prior studies [7, 8, 29].

Our results indicate that stroke hospitalizations for the very old are less likely to occur at teaching centers. This finding, plus our observation that hospitalizations

Table 3. Factors associated with in-hospital mortality or discharge to a long-term care facility

Variable	Adjusted OR	
	< 85 years	≥ 85 years
Age, years	1.05 (1.04–1.05)	1.02 (1.00–1.05)
Female gender	1.12 (1.03–1.20)	1.40 (1.18–1.68)
Atrial fibrillation	1.14 (1.03–1.26)	1.37 (1.15–1.63)
Acute myocardial infarction	1.68 (1.20–2.35)	1.68 (1.20–2.35)
Respiratory failure	3.58 (2.67–4.78)	3.59 (1.60–8.05)
Teaching hospital	0.92 (0.85–1.00)	0.82 (0.69–0.98)
Florida	0.84 (0.74–0.96)	0.79 (0.60–1.03)
Maryland	0.82 (0.66–1.03)	0.44 (0.27–0.72)
North Carolina	1.15 (0.98–1.35)	0.70 (0.48–1.01)
New Jersey	0.74 (0.60–0.92)	0.69 (0.46–1.05)
New York	0.77 (0.66–0.90)	0.61 (0.45–0.84)
South Carolina	0.76 (0.60–0.97)	0.96 (0.50–1.83)
Tennessee	0.82 (0.66–1.02)	1.12 (0.70–1.79)
Texas	1.07 (0.94–1.23)	0.72 (0.54–0.96)
Virginia	0.75 (0.60–0.95)	0.31 (0.19–0.51)

Figures in parentheses are 95% CI.

for very old patients were associated with fewer procedures, may suggest that very old stroke patients receive less aggressive care compared with younger ones. Although the HCUP data may underreport procedures overall, it is unlikely that differential procedure reporting

would occur by age; it rather varies among hospitals. Prior investigations have described less intensive care for very old stroke patients [5, 7, 30]. For example, in a study of 100 black patients ≥ 85 years and 480 patients < 85 years from Martinique, the very old were less likely to be admitted to a neurology ward (8 vs. 24%, $p < 0.001$) or to receive brain imaging (82 vs. 94%, $p < 0.0001$) [7].

We performed multivariable modeling to identify factors that were associated with poor outcomes for stroke patients (death or institutionalization). Among the very old, we found that age was independently related to in-hospital mortality or discharge to a long-term care facility. Although age has been identified as an independent predictor of death and institutionalization in numerous studies, to our knowledge, none has examined this issue restricted to very old patients. Future research should examine the role of age in prognostication for very old stroke patients.

The multivariable analysis results also indicated that very old patients who were admitted to a teaching hospital had better outcomes than very old subjects admitted to non-teaching centers. Future studies should be directed at confirming this finding and identifying the differences in patient characteristics or stroke care that can account for the discrepancies in patient outcomes.

Geographic variation in poststroke outcomes, especially in poststroke mortality, has been demonstrated previously [31]. The southern part of the USA has the highest rate of poststroke mortality and is often referred to as the Stroke Belt. Recently, studies have indicated that the absolute differences in mortality rates may be varying and the specific states with the highest poststroke mor-

tality may be changing with time [31]. Our findings differ from the previous literature in terms of the precise states with the lowest mortality. Also, little of the previous literature has focused on the differences in geographic variation (e.g. the specific states where the outcomes are either worse or better) between very old and younger stroke patients. Howard et al. [32] compared poststroke mortality in the Stroke Belt to the non-Stroke-Belt states by age and race/ethnicity groups, finding that the mortality differences were pronounced for very old Whites but with less geographic variation in outcome for very old Blacks.

Conclusions

Our research findings suggest that the very old constitute a large proportion of ischemic stroke hospitalizations and that they are more likely to suffer adverse outcomes after stroke than younger patients. Future studies of ischemic stroke should examine very old patients and should be directed toward reducing age-based disparities in outcomes.

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