

Trends in Outcome and Hospitalization Cost among Adult Patients with Acute Ischemic Stroke in the United States

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Abstract

Introduction—New treatments for acute ischemic stroke (AIS) have been introduced and are expected to improve patients' overall outcomes. We assessed the impact of new therapeutic strategies on outcome and cost of hospitalization among adult patients with AIS in the United States.

Methods—Patients with AIS admitted in the United States in 1993–1994 and 2006–2007 were listed using the Nationwide Inpatient Survey database. We determined the rates of occurrence, hospitalization outcomes, and mean hospital charges for all patients. We further analyzed these variables in the ventilated and nonventilated patients.

Results—We identified 386,043 patients with AIS admitted in the United States in 1993–1994 and 749,766 patients in 2006–2007. The length of hospitalization was significantly higher in 1993–1994 compared with 2006–2007: 6.9 ± 4.2 days versus 4.66 ± 3 days, respectively. In-hospital mortality rate was 8.9% in 1993–1994 and 5.6% in 2006–2007 ($P < 0.0001$). There was a significant increase in mean hospital charges in 2006–2007 compared with 1993–1994 ($\$21,916 \pm \$14,117$ versus $\$9,646 \pm \$5,727$). The length of hospitalization was significantly shorter in 2006–2007 in nonventilated patients. There was a significant increase in mean hospital charges in 2006–2007 compared with 1993–1994 in both ventilated ($\$81,528 \pm \$64,526$ versus $\$25,143 \pm \$17,172$, $P < 0.0001$) and nonventilated patients ($\$21,085 \pm \$13,042$ versus $\$10,000 \pm \$6,300$, $P < 0.0001$). The mortality rate was significantly lower in 2006–2007 in both subgroups: 46.5% versus 59.8% in ventilated patients and 4.2% versus 8.2% in nonventilated patients ($P < 0.0001$).

Conclusion—Our study suggests that new therapeutic strategies have improved outcomes and increased cost of hospitalization among adult patients with AIS in the United States over a period of 13 years. The hospitalization cost was significantly higher in the ventilated and nonventilated patients in 2006–2007, which may reflect the impact of new therapeutic strategies, the availability of more intensive care units and stroke centers, and the lower mortality rate in this time period.

Keywords

acute ischemic stroke; cost; outcome; length of stay; mortality

Introduction

Stroke is the third most common cause of death in the western countries [1–3] and remains a major cause of disability and mortality in the United States [4–6]. Stroke, of which most cases are ischemic, affects patients in all age groups and is a major source of morbidity in adults [4–6]. As the understanding of the pathogenesis and risk factors of acute ischemic stroke (AIS) has advanced in the past two decades, new therapeutic strategies have been introduced, including the implementation of stroke units, expanding the window of opportunity of intravenous thrombolysis to 4.5 hours, and the introduction of intra-arterial thrombolysis and thrombectomy [7]. These new strategies are expected to improve the associated in-hospital outcomes, mortality rates, and costs of hospitalization; however, their impact on mortality and cost remains to be determined. The objective of this study was to evaluate the impact of new therapeutic strategies on outcome and cost of hospitalization among patients with AIS in the United States over a period of 13 years, between 1993–1994 and 2006–2007.

Design and Methods

We used the data from the Nationwide Inpatient Sample (NIS) sponsored by the Agency for Healthcare Research and Quality [8,9]. The NIS, the largest inpatient all-payer database in the United States, is designed to identify, track, and analyze national trends in health care utilization, access, charges, quality, and outcome. It contains data from approximately 5–8 million hospital stays and includes all discharge data from approximately 1000 hospitals located in 40 states. This data sample constitutes approximately a 20% stratified sample of United States community hospitals [10]. Briefly, the NIS database includes data on more than 100 clinical and non-clinical variables associated with hospital stays, including primary and secondary diagnoses, primary and secondary procedures, patients' admission and discharge status, patient demographic information (i.e., sex, age, race, median income, or zip code), expected payment source, total charges, and length of stay.

We identified patients over the age of 18 years using the *International Classification of Disease, 9th Revision, Clinical Modification (ICD-9-CM)* code for primary diagnosis of AIS, (434 and 436) and either primary or secondary procedure codes for continuous mechanical ventilation [967, 967.0, 967.1, 967.2]. In 1993–1994, treatment modalities for AIS were limited, whereas in 2006–2007, several strategies were widely available,

including specialized neuro-intensive care units and the use of intravenous and intra-arterial thrombolysis. We determined the rates, hospital outcomes, and charges incurred among patients hospitalized with AIS in 1993–1994 and compared these variables with those in 2006–2007. Variables analyzed included age, sex, race/ethnicity, length of stay, discharge status (categorized into routine, home health care, short-term hospital, other facility, including intermediate care and skilled nursing home, or death), and total hospitalization charges. We used SPSS version 17 (SPSS, Inc., Chicago, IL) to convert raw counts generated from the NIS database into weighted counts, from which we generated national estimates. We used the chi-square test for categorical data and analysis of variance for continuous data to detect any significant differences between 1993–1994 and 2006–2007. We adjusted for the influence of inflation on differences in hospital charges between the two time periods, and used data from the Consumer Price Index (CPI) to adjust for average change in prices related to inflation [11].

Results

Demographics and clinical characteristics

We identified 386,043 patients with AIS stroke admitted in the United States in 1993–1994 and 749,766 patients in 2006–2007. The demographic and clinical characteristics of identified patients are summarized in Table 1. The average age (in years \pm SD) was 73.50 ± 12.50 and 71.65 ± 14.70 for 1993–1994 and 2006–2007, respectively. The proportion of women patients was higher in both time periods.

In-hospital outcomes

The length of hospitalization was significantly higher in 1993–1994 compared with 2006–2007: 6.90 ± 4.20 days versus 4.66 ± 3.00 days, respectively ($P < 0.0001$). The in-hospital mortality was 8.9% in 1993–1994 and 5.6% in 2006–2007 ($P < 0.0001$). The proportion of patients transferred to short-term hospitalization centers, skilled nursing facilities, and intermediate care centers was significantly higher in 2006–2007 ($P < 0.0001$).

Total hospitalization charges

There was a significant increase in mean hospital charges in 2006–2007 compared with 1993–1994 ($\$21,916 \pm \$14,117$ versus $\$9,646 \pm \$5,727$, $P < 0.0001$); this difference remained significant even after adjusting for inflation (Table 1).

Subgroup analysis by mechanical ventilation

When we compared trends in outcome in ventilated and nonventilated patients with AIS in the two time periods,

Table 1. Trends in outcome and hospitalization cost among adult patients with AIS in the United States in 1993–1994 and 2006–2007

Characteristics	1993–1994	2006–2007
Total number of patients	386,043	749,766
Mean age (y, SD)*	73.50 ± 12.50	71.65 ± 14.70
Sex*		
Men	174,986 (45.3%)	339,087 (45.2%)
Women	211,041 (54.7%)	410,470 (54.8%)
Race/ethnicity		
White*	235,767 (61.1%)	383,803 (51.2%)
African-American*	41,517 (10.7%)	90,422 (12.1%)
Other*	108,759 (28.2%)	275,541 (36.7%)
Length of stay (mean days, SD)*	6.90 ± 4.20	4.66 ± 3.00
Discharge status		
Routine*	149,093 (38.7%)	261,628 (34.9%)
Transfer to short-term hospitals*	12,897 (3.3%)	24,005 (3.2%)
Others (skilled nursing facilities, home health care, and other disposition)*	189,620 (49.1%)	421,866 (56.3%)
Died in hospital (mortality)*	34,433 (8.9%)	42,267 (5.6%)
Mean unadjusted hospitalization charges*, SD	\$9,646 ± 5,727	\$21,916 ± 14,117
Mean hospitalization charges adjusted to inflation	\$13,306	

* Statistically significant ($P < 0.05$)

Table 2. Trends in outcome and hospitalization cost among adult patients with AIS in the United States in 1993–1994 and 2006–2007: ventilated versus nonventilated patients.

Characteristics	Ventilated Patients		Nonventilated Patients	
	1993–1994	2006–2007	1993–1994	2006–2007
Total number of patients	5,506	25,922	380,537	723,844
Mean age (y, SD)*	71.4 ± 13.3	68.8 ± 15.0	73.5 ± 12.5	71.75 ± 14.7
Sex				
Men	2,770 (50.3%)	13,207 (51%)	172,216 (45.3%)*	325,879 (45%)
Women	2,735 (49.7%)	12,710 (49%)	208,306 (54.7%)*	397,760 (55%)
Race/ethnicity				
White*	3,338 (60.5%)	12,050 (46.4%)	232,430 (61.1%)	371,753 (51.5%)
African-American*	717 (13%)	4,093 (15.8%)	40,800 (10.7%)	86,329 (11.9%)
Other*	1,451 (26.5%)	9,779 (37.8%)	107,304 (28.2%)	265,762 (36.6%)
Mean length of stay (days, SD)*	10.0 ± 8.0	11.0 ± 9.0	6.6 ± 3.8	4.33 ± 2.5
Discharge status				
Routine*	584 (10.6%)	1,692 (6.5%)	148,511 (39%)	259,936 (36%)
Transfer to short-term hospitals*	227 (4.1%)	1,276 (4.9%)	12,670 (3.3%)	22,730 (3.1%)
Others (skilled nursing facilities and other disposition)*	1,400 (25.4%)	10,909 (42.0%)	188,218 (49.5%)	410,956 (56.8%)
Died in hospital (mortality)*	3,295 (59.8%)	12,045 (46.5%)	31,138 (8.2%)	30,222 (4.2%)
Mean unadjusted hospitalization charges*, SD	\$25,142 ± 17,172	\$81,528 ± 64,526	\$10,000 ± 6,300	\$21,085 ± 13,042
Mean charges adjusted to inflation	\$34,700		\$13,800	

* Statistically significant ($P < 0.05$)

we found that the length of hospitalization stay was significantly shorter in 2006–2007 in nonventilated patients: 4.33 ± 2.5 days versus 6.6 ± 3.8 days ($P < 0.0001$) (Table 2). The length of hospitalization stay, however, was longer in ventilated patients in 2006–2007: 11 ± 9 days versus 10 ± 8 days ($P < 0.0001$).

There was a significant increase in mean hospital charges in 2006–2007 compared with 1993–1994 in both ventilated ($\$81,528 \pm \$64,526$ versus $\$25,143 \pm \$17,172$, $P < 0.0001$) and nonventilated patients ($\$21,085 \pm \$13,042$ versus $\$10,000 \pm \$6,300$, $P < 0.0001$).

Death rate was significantly lower in 2006–2007 than in 1993–1994 in both subgroups: 46.5% versus 59.8% in ventilated patients and 4.2% versus 8.2% in nonventilated patients ($P < 0.0001$).

Discussion

Salient findings of the study

Over a span of 13 years (1993–1994 and 2006–2007), the following statistically significant trends were observed among patients admitted with AIS in the United States:

1. More women patients were admitted with AIS in both time periods.
2. Length of hospitalization in the 2006–2007 time period was significantly shorter in nonventilated patients.
3. There was a significant increase in the number of patients transferred to short-term facilities and rehabilitation centers in the 2006–2007 time period.

4. Significant increase in the cost of hospitalization in 2006–2007 was noted.
5. There was a significant reduction of in-hospital mortality rate in the 2006–2007 time period.

Comparison with previous studies

With improved treatment strategies of AIS, the mortality rate has dramatically improved over the past few years. The pertinent findings outlined above are supported by reports of previous studies. Tong *et al.* [12] found that the mortality rate was lower in 2006–2007 compared with 1998–1999 in patients with AIS. Using 1998 to 1999 as the referent, the adjusted odd ratio for in-hospital mortality was 0.75 (95% confidence interval: 0.72 to 0.79) in 2006–2007, $P < 0.001$. There was a female patient predominance. The length of in-hospital stay was 5.56 days in 1998–1999 compared with 4.77 days in 2006–2007, $P < 0.001$ [12]. Ovbiagele *et al.* [4] reported a decrease in mortality rate in patients hospitalized with AIS between 1996 and 2007 regardless of age and sex, except in men over 84 years of age ($P < 0.01$). A decrease in mortality rate in stroke patients has also been reported in European countries between 1980 and 2005 [2]. In a retrospective study conducted at Brigham and Women's Hospital, the lengths of stay (LOS) of 745 patients aged 65 or older and admitted with ischemic stroke from 1982 to 1996 were reviewed. Among patients with AIS there was a marked variability in LOS, with an overall median of seven days. Insurance status was a major factor in determining LOS: patients who had private insurance had a shorter LOS (odds ratio [OR], 0.45; 95% confidence interval, 0.31–0.66) compared with patients who had Medicare insurance coverage. LOS was not influenced by age, sex, or race. Discharge to a nursing home or an inpatient rehabilitation center was not associated with the type of insurance coverage [13].

Potential explanations for the observed findings

In-hospital outcomes—The shorter length of stay observed in 2006–2007 in our study could be attributed to the availability of efficient stroke teams of clinicians and nurses, in collaboration with social services and discharge planning, leading to proficient patient turn-over [14]. The increased availability of short-term rehabilitation centers, skilled nursing facilities, and home-health aid services further contributes to the shorter LOS of patients hospitalized with AIS in 2006–2007 [12].

In-hospital mortality—Common medical complications associated with AIS are associated with increased

mortality. A recent study showed that several medical complications in stroke patients, including deep vein thrombosis and pulmonary embolism, were more common in 2006–2007 than eight years earlier [12]. Despite this trend, our study showed that the in-hospital mortality rate among patients with AIS was significantly lower in 2006–2007. This can be explained by the improved treatment strategies, intensive care measures, and invasive and noninvasive interventions in acute stroke patients. The rapid development in the field of neurological endovascular intervention and treatment of AIS may also account for the lower mortality rate observed in 2006–2007 [14]. Furthermore, the multidisciplinary approach to inpatient stroke care has greatly contributed to the decreased mortality associated with ischemic stroke and its consequent medical complications. A recent case-cohort study of patients with AIS presenting between July 2003 and March 2005 showed that organized stroke units and inpatient care are associated with reduced mortality rate with a comparable magnitude of effect across all age groups [14].

Total hospitalization charges—Despite a shorter hospitalization stay of patients with AIS, there was an increase in hospitalization cost in 2006–2007, even after adjusting for inflation. This may be attributed to the higher costs of new therapeutic methods, intensive care, and endovascular intervention. Current treatments for AIS focus on restoring or improving perfusion to the ischemic brain region using thrombolytics and mechanical thrombectomy, which has contributed markedly to the increased cost of hospital stay [15].

Subgroup analysis by mechanical ventilation—There was a significant decrease in mortality rate in 2006–2007 in both ventilated and nonventilated patients with AIS. This explains that other measures besides mechanical ventilation have contributed to the lower mortality rate in 2006–2007, as nonventilated patients in this time period had a significant drop in mortality rate as well. The length of hospitalization was shorter in 2006–2007 in nonventilated patients only, which is likely due to the factors outlined above. However, in ventilated patients, the length of hospitalization was significantly longer in 2006–2007, which is likely related to the increased availability of intensive care, mechanical ventilation, and advanced therapeutic interventions for patients with severe AIS over the span of 13 years. The cost of hospitalization was higher in both subgroups after adjusting for inflation, likely due to the higher cost of rapidly advancing diagnostic and therapeutic measures in the field.

Conclusion

There was a significant increase in mean hospitalization charges in patients admitted with AIS that paralleled a significant reduction in mortality and average length of hospitalization in 2006–2007 compared with 1993–1994. This may reflect the impact and cost of new therapeutic strategies and the availability of more intensive care units and stroke centers. The availability of skilled-nursing facilities and rehabilitation centers may contribute to the reduction of average LOS in patients hospitalized with AIS.

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