Mortality rates, hospital length of stay, and the cost of treating subarachnoid hemorrhage in older patients: institutional and geographical differences

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The risk of disability and death and the cost of medical care are particularly high for patients with aneurysmal subarachnoid hemorrhage (SAH) who are 65 years of age or older. A retrospective analysis of 47,408 Medicare patients treated over an 8-year period was performed to determine whether a relationship exists between the mortality rate and surgical volume for older patients with SAH. The mortality rate, length of stay in the hospital, and cost of treatment for patients with SAH in California and New York were also compared. The mortality rate was 14.3% for patients with SAH who were 65 years old or older and who were treated surgically in hospitals in which an average of five or more craniotomies were performed per year; in hospitals averaging between one and five craniotomies annually the mortality rate was 18.4%; and in those averaging less than one such operation per year the rate was 20.5% (trend $p = 0.01$). There was no difference in the mortality rate for patients in California versus the rate for those in New York. Surgically and medically treated patients, respectively, left the hospital an average of 6.7 and 5.1 days sooner in California than in New York. The unadjusted average reimbursement from Medicare to hospitals for surgically treated patients averaged \$1468 more in New York than in California ($p < 0.0001$), but was equivalent for medically treated patients in the two states. The mortality rate in older patients who are treated surgically for SAH may be inversely correlated with the annual number of craniotomies performed for SAH in patients 65 years of age or older at a given institution. Hospital stays for patients with SAH are significantly shorter in California than in New York.

Key Words * subarachnoid hemorrhage * mortality rate * epidemiological study * length of stay * cost analysis

The mortality rate from subarachnoid hemorrhage (SAH) is as high as 50%,[21,24] and many patients who survive this devastating illness experience significant morbidity. Patients 65 years of age or older are at a particularly high risk for death from aneurysmal bleeding.[10,11,13,15,20,25,29] This increased risk has acquired greater significance because this age group constitutes an increasingly large segment of the U.S. population. An inverse relationship between the number of surgical procedures performed and mortality rates has been well described for coronary artery bypass grafts.[16,22,26] This association exists whether the number of procedures performed at each hospital or by individual surgeons is measured[5,7,8] and is independent of clinical risk factors and demographic variables.[7] Volume is a

predictor of complications for some, but not all, general surgical operations,[8,16,22,27] and it has been suggested that the volume-mortality relationship does not exist for less complicated procedures. In New York state, the decreased mortality rate for coronary artery bypass graft operations performed at higher-volume hospitals and by surgeons with more experience in performing this procedure is believed to have lowered the mortality rate for operations treating coronary artery disease.[5] This decrease in the mortality rate is attributed to a decrease in the number of surgeons in the state who perform only a few of these procedures and improved performance by the increased number of high-volume surgeons. It is not known if similar improvements may be made in other types of technically demanding surgery. A large, multicenter study of patients with SAH found no association between surgical volume and mortality rates,[13] but a more recent study of hospitals in New York state showed a decrease in mortality rates with an annual increase in the number of craniotomies performed for aneurysm clipping.[28] The first goal of this study was to determine if mortality rates in older individuals with nontraumatic SAH can be predicted throughout the U.S. by the number of older patients treated surgically for SAH in a given hospital.

Subarachnoid hemorrhage is associated not only with significant rates of mortality and disability, but with substantial economic cost and requirements for hospital services as well. Limited resources have prompted close scrutiny of disparities in the utilization and cost of health care services between different geographic locations and patient populations. Most studies have shown that the average length of hospital stay (LOS) for patients in West Coast hospitals is significantly shorter than that on the East Coast.[1,14,23] Whereas the cost of medical care is increasing for all patients, the relative cost of providing services to patients 65 years of age or older increased more rapidly between 1970 and 1990 than for any other age group,[18] and a recent report has shown that the cost of treating patients with SAH who are 65 years of age or older is 1.5 times greater than the cost of treating those younger than 65 years of age.[29] The second goal of this study was to determine if the mortality, duration of hospital stay, and cost of treatment for SAH in older patients differ between two geographically distinct regions within the U.S.

CLINICAL MATERIAL AND METHODS

Medicare Database

Data were obtained from the Health Care Financing Administration database for Medicare patients hospitalized in the 8-year period from 1984 through 1991. Medicare enrolls 96% of U.S. citizens 65 years of age and older.[4] This database contains discharge summaries for all hospital stays of Medicare patients within the U.S. and has been the basis of recent studies of the mortality rate and complications associated with coronary artery bypass graft surgery, coronary angioplasty, lumbar spine surgery, hip surgery, and the risk of SAH in older patients with unruptured cerebral aneurysms.[12,17,19,22,30] Information obtained for each patient includes a unique identifier, age, gender, race, total hospital charges to Medicare (not including physician charges), total reimbursement to the hospital from Medicare, the date of admission, and the date of discharge or death (if death occurred within 2 1/2 years of admission). For each admission a primary diagnosis, up to four secondary diagnoses (comorbidities) and up to three procedures may be recorded. The Hunt and Hess[9] grade at the time of admission is not available from this database.

Exclusion Criteria

Records for all individuals 65 years of age and older who were admitted to any acute-care hospital in the

U.S. with a diagnosis of SAH (code 430) according to the International Classification of Diseases, Ninth Revision (ICD.9.CM) were abstracted for this study. Data from the first admission only were used for patients admitted more than once with the diagnosis of SAH. Patients with evidence of traumatic injury at the time of admission (ICD.9.CM 800-854.99) were excluded from the study. To remove outliers who may have skewed the calculation of average hospital LOS and average cost, the 1% of patients with the longest LOS were also excluded. Surgical treatment was determined by an appropriate procedure code (ICD.9.CM 383.1-2, 384.1-2, 386.1-2, 388.1-2, 395.1-2). The mortality rate was defined as the percentage of patients who were deceased 30 days from the date of admission for SAH.

Surgical Volume

To determine the role of surgical volume in mortality rates, patients from all 50 states who were treated surgically were separated and grouped by provider (hospital) code, and the average number of patients 65 years of age or older with SAH who were treated surgically each year was determined for each hospital. Hospitals were then grouped according to volume, and the mortality rate for surgically and medically treated patients in each group was determined.

Geographic Comparisons

In a separate analysis, patients were grouped according to the state in which they were hospitalized, and overall surgical mortality rates were determined for each state. Demographic variables, the average LOS, the average hospital charges to Medicare, and the average reimbursement from Medicare were compared between the two states in which the largest number of patients were treated for SAH. Univariate and multivariate analyses were performed.

Statistical Analyses

Continuous and dichotomous variables were compared using the two-sampled t-test and the chi-square test, respectively. Trends were evaluated using Mantel-Haenzsel statistics. For all comparisons, statistical significance was set at $p < 0.01$. Analyses were performed using commercially available software (SAS/Graph, Version 6; SAS Institute, Cary, NC).

TABLE 1 CHARACTERISTICS OF PATIENTS WITH SAH TREATED BETWEEN 1984 AND 1991 WHO WERE 65 YEARS OF AGE OR OLDER*				
Characteristic	All Patients	Treatment Modality		p Value
		Surgical	Medical	
no. (%)	47,408	6,760 (14.3)	40,648 (85.7)	—
mean age (SD)	74.9 (7.3)	71.1 (6.2)	75.6 (7.4)	0.001
female (%)	32,996 (69.6)	5,280 (78.1)	27,722 (68.2)	0.001
caucasian (%)	40,818 (86.1)	5,766 (85.3)	35,039 (86.2)	0.049
mean no. of comorbidities	2.8	3.1	2.8	<0.0001
30-day mortality rates (%)	23,277 (49.1)	1,299 (19.2)	21,957 (54.0)	<0.0001
* Includes patients from all 50 states in the U.S. Abbreviation: SD = standard deviation.				
† The probability value is for the comparison of medically versus surgically treated patients.				

RESULTS

During the 8 years studied, 53,121 Medicare patients 65 years of age or older were admitted with an initial diagnosis of SAH. A total of 5238 patients were excluded: 816 for concurrent diagnosis of traumatic injury and 4422 for admission to nonacute-care facilities. Exclusion of the 1% of patients with the longest hospital stays left 47,408 patients for this analysis; 69.6% were women. The characteristics of these patients are shown in Table 1. The majority of patients were treated medically (85.7%) and had a much higher risk of death (54%) than those patients selected for surgical treatment (19.2%, $p < 0.0001$). Surgically and medically treated patients had approximately the same number of comorbidities recorded at the time of discharge.

TABLE 2 THE 30-DAY MORTALITY RATES FOR SURGICALLY AND MEDICALLY TREATED PATIENTS WITH SAH VERSUS THE NUMBER OF OLDER PATIENTS TREATED SURGICALLY PER HOSPITAL PER YEAR*				
Average No.†	Surgically Treated Patients		Medically Treated Patients	
	Total No.	Mortality Rate(%)‡	Total No.	Mortality Rate(%)§
0	NA	NA	15,051	7,696 (51.1)
<1	3,144	643 (20.5)	17,300	9,668 (55.9)
1 to <3	2,988	550 (18.4)	7,427	4,113 (55.4)
3 to <5	397	73 (18.4)	583	335 (57.5)
>5	231	33 (14.3)	287	145 (50.5)
* Includes patients from all 50 states in the U.S. Abbreviation: NA = not applicable.				
† Average number of patients with SAH treated surgically per hospital per year.				
‡ For decreasing mortality: $p = 0.01$.				
§ For increasing mortality: $p < 0.0001$.				

The average annual number of craniotomies performed per hospital for SAH in patients 65 years of age or older versus the medical and surgical mortality rates for SAH is shown in Table 2. These numbers are not representative of, but are probably correlated with, the annual surgical volume for patients of all ages with aneurysm rupture at each hospital. Because the number of older patients who are treated surgically is small, 75% of patients were treated in hospitals in which an average of no craniotomy or an average of less than one was performed annually for SAH in a patient 65 years of age or older. The mortality rate was 14.3% for older patients treated surgically in hospitals averaging five or more craniotomies per year; in hospitals averaging between one and five craniotomies in older patients annually it was 18.4%; and in those averaging less than one such operation per year it was 20.5% (trend $p = 0.01$). All patients treated in hospitals that averaged five or more operations per year for SAH in an older patient were treated in teaching hospitals (as designated by Medicare). The surgical mortality rate for patients in teaching hospitals that averaged three to five craniotomies per year was 16.3%, compared to 23.1% in nonteaching hospitals with the same surgical volume ($p < 0.0001$). The surgical mortality rate for patients treated in hospitals that averaged less than three operations per year for SAH in patients 65 years of age or older was 19.5% in nonteaching hospitals and 19.3% in teaching hospitals ($p =$ not significant).

For medically treated patients the mortality rate was positively correlated with annual surgical volume (trend $p < 0.0001$). This trend became nonsignificant if the 870 medically managed patients treated in hospitals averaging three or more craniotomies per year were analyzed as one group.

TABLE 3
CHARACTERISTICS OF OLDER PATIENTS WITH SAH IN CALIFORNIA AND NEW YORK*

Characteristic	All Patients		p Value	Surgically Treated Patients		
	California	New York		California	New York	p Value
no.	4,613	3,180	NA	747 (16.2)	324 (10.2)	<0.0001
mean age (SD)	75.1 (7.3)	75.4 (7.5)	0.183	71.3 (5.2)	70.5 (4.9)	0.009
female (%)	3,178 (68.9)	2,258 (71.0)	0.045	505 (67.6)	226 (69.8)	0.047
caucasian (%)	3,930 (85.2)	2,684 (84.4)	0.346	638 (85.4)	274 (84.7)	0.319
mean no. of comorbidities	2.9	2.8	0.056	3.1	3.1	0.75
30-day mortality rate (%)	2,283 (49.5)	1,644 (51.7)	0.062	152 (20.4)	65 (20.1)	0.915

* NA = not applicable; SD = standard deviation.

Significant differences did not exist in the unadjusted mortality rates of all patients or surgically treated patients with SAH when compared among the 50 states (data not shown). California and New York had the highest number of admissions for SAH, 4613 and 3180, respectively (Table 3); the age, gender, race, and number of comorbidities present at admission were closely matched between these two populations. A significantly greater number of patients were selected for surgical treatment in California (16.2%) than in New York (10.2%) ($p < 0.0001$), but because of the small number of patients treated surgically there was no overall difference in mortality rates between these two states.

TABLE 4
THE LOS, HOSPITAL CHARGES TO MEDICARE, AND REIMBURSEMENT TO HOSPITALS FROM MEDICARE FOR OLDER PATIENTS WITH SAH IN CALIFORNIA AND NEW YORK BETWEEN 1984 AND 1991*

Treatment Group	California	New York	p Value
surgical			
mean LOS	22.6 days (13.6)	29.3 days (19.6)	<0.0001
mean charge	\$46,690 (\$26,462)	\$33,870 (\$21,619)	<0.0001
mean reimbursement	\$15,252 (\$5,268)	\$16,720 (\$7,920)	0.004
medical			
mean LOS	10.3 days (10.5)	15.4 days (17.5)	<0.0001
mean charge	\$17,591 (\$18,568)	\$12,395 (\$14,288)	<0.0001
mean reimbursement	\$6,447 (\$4,689)	\$6,304 (\$5,714)	<0.3

* "Charge" refers to the charge from hospitals to Medicare in U.S. dollars; "reimbursement" means the reimbursement from Medicare to hospitals in U.S. dollars. Numbers in parentheses are the standard deviation.

The average LOS, charges from hospitals to Medicare, and reimbursement from Medicare to hospitals for medically and surgically treated patients in California and New York are shown in Table 4 and the 8-year trends are shown in Fig. 1. Although the mortality rate was the same, the hospital stay for patients over 65 years old with SAH was significantly shorter in California than in New York. Surgically treated patients left the hospital an average of 6.7 days sooner and medically treated patients left 5.1 days sooner in California than in New York. Hospital charges billed to Medicare for surgical and medical treatment were 1.4 times higher in California than in New York. However, the unadjusted average reimbursement from Medicare to hospitals for surgically treated older patients with SAH was \$1468 more for patients in New York as compared to those in California (\$16,720 and \$15,252, respectively; $p = 0.004$). When adjusted for LOS, reimbursement for patients treated surgically averaged \$1249 higher in California than in New York. Unadjusted reimbursement for medically treated patients averaged \$6447 in California and \$6304 in New York ($p =$ not significant). This difference did not become statistically significant when multivariate analysis was performed.

Fig. 1. Upper: Graph showing the average LOS for older patients with SAH in California (CA) and New York (NY) from 1984 through 1991. Center: Graph showing the average charge from hospitals to Medicare for older patients with SAH in CA and NY from 1984 through 1991. Lower: Graph showing the average reimbursement from Medicare to hospitals for older patients with SAH in CA and NY from 1984 through 1991.

As shown in Fig. 1 upper, hospital stays for medically treated patients in California declined from an average of 11.6 days in 1984 to 8.2 days in 1991 ($p < 0.0001$), whereas the average LOS for all other groups remained essentially the same. The decline in average LOS for medically treated patients in California was not associated with a statistically significant change in mortality rates (data not shown). Hospital charges to Medicare for both medically and surgically treated patients increased significantly over the 8-year period in both states (trend $p < 0.0001$ for all groups; Fig. 1 center). Average hospital charges to Medicare for surgically treated patients in California and New York were \$29,503 and \$23,659, respectively, in 1984 and \$60,395 and \$44,160, respectively, in 1991. Reimbursement from Medicare to hospitals for both medically and surgically treated patients in the two states also increased significantly over the 8 years studied (trend $p < 0.0001$ for all groups; Fig. 1 lower). Reimbursement from Medicare to hospitals for surgically treated older patients averaged \$11,673 and \$12,309 for California and New York, respectively, in 1984 and \$24,721 and \$25,567, respectively, in 1991.

DISCUSSION

We have compared the mortality rates of surgically treated and medically managed older patients with SAH. A significant difference in the outcome of patients treated surgically versus those treated medically

is not unexpected because the surgically treated patients in this study represent a nonrandomized group, most likely selected for operation on the basis of their Hunt and Hess grade at presentation and their overall ability to survive the stress of a craniotomy.

This study of Medicare patients treated in hospitals of all sizes across the U.S. indicates that an increased volume of craniotomies in a given hospital for patients with SAH who are 65 years of age or older is correlated with a lower rate of surgical mortality. Mortality rates for patients with SAH in any given hospital reflect a large number of variables including patient referral patterns and the availability, experience, and skill of physicians and other hospital staff treating these patients. Hospitals with lower surgical volumes may have physicians who are likely to transfer stable patients to a regional referral center, but who more frequently admit to their own institution patients who are considered medically unstable for transport. This may also explain the lower mortality rate at higher-volume hospitals, if these centers preferentially receive patients in better medical condition and with lower Hunt and Hess grades. Patients receiving surgical treatment in higher-volume hospitals are also likely to benefit from surgeons with more experience in postoperative monitoring of patients and in diagnosing and treating complications of SAH including vasospasm. Finally, a greater volume of surgery for SAH in older patients at specific hospitals may correlate with the amount of experience that individual surgeons have in treating these patients.

The International Cooperative Study on the Timing of Aneurysm Surgery[13] compared the mortality rates for patients with SAH among 58 neurosurgical centers in 14 countries. Participating institutions averaged at least six admissions for SAH per year and treated 83% of their patients surgically. No association was found between patient volume and overall mortality rates. The investigators were predominantly surgeons, all of whom had an academic interest in improving the care of patients with cerebrovascular disease. This, in combination with the relatively high volume of surgery at each of the participating hospitals, probably accounts for the lack of a volume/mortality relationship in the Cooperative Study. More recently, Solomon, et al.,[28] studied the Statewide Planning and Research Cooperative System database from New York state and identified 4034 patients who underwent craniotomy for SAH over a 7-year period. Hospitals in which more than 30 such operations were performed annually had an in-hospital mortality rate that was 43% lower than for hospitals in the rest of the state in which fewer of these procedures were performed.

We have not attempted to define a critical number of craniotomies per year after which the mortality rate becomes "acceptable," because the majority of surgically treated patients in this study were treated at hospitals in which, on average, less than one operation per year was performed in a patient 65 years of age or older. Statistically, if the surgical mortality rate of the patients undergoing aneurysm clipping at the hospitals with the lowest volume of these procedures had equaled the mortality rate in hospitals in which five or more craniotomies are performed per year, an additional 193 patients would have survived their hemorrhage.

Sixteen percent of patients in California underwent operation, whereas only 10% of patients in New York state were treated surgically. Although demographic variables and the average number of comorbidities are similar between patients in these two states, it appears that physicians on the West Coast are somewhat more likely to treat older patients with SAH surgically than are their East Coast colleagues. The fact that this was accomplished without an increase in the surgical mortality rate indicates that operative management may be warranted in this population. The overall mortality rate was unaffected by the slightly larger number of surgical procedures performed in California.

Whether patients were managed surgically or medically, the average hospital stay for SAH was 5 to 7 days shorter in California than in New York, but, unexpectedly, resulted in a much higher hospital charge to Medicare for patients treated on the West Coast. The significant differences in LOS and charges remained when either the mean or median was calculated and when the 5% of patients with the longest or most expensive hospital stays were excluded (data not shown). Elliott, et. al.,[2] recently reported a cohort of 543 patients with a median age of 51 years (range 5-91 years) who were admitted for management of unruptured aneurysms or aneurysmal SAH between 1983 and 1993. Except for patients in Hunt and Hess Grade V, median LOS and mean hospital charges increased with increasing grade on admission. Unfortunately, Hunt and Hess grades were not available for the patients described in this study.

Reimbursement from Medicare is based on the diagnosis-related group of a given disease as identified by its ICD.9.CM code. Reimbursement, determined by the Health Care Financing Administration, is calculated as the mean of all Medicare claims in a designated base year and is updated annually for inflation. Adjustment is made for individual hospitals based on the prevailing wage rate in the hospital's location, presence of a teaching program, and treatment of a disproportionate share of indigent patients.[3] Reimbursement is only adjusted for the LOS when the latter exceeds 30 days. In this study, reimbursement was higher for patients treated surgically in New York as compared to those treated in the same manner in California, but was equivalent for medically treated patients in the two states.

The trend analysis shows that, except for medically treated patients in California, the LOS remained relatively constant during the 8-year study period. Both hospital charges and reimbursement to hospitals from Medicare increased significantly from 1984 through 1991. The information in this database does not allow for further explanation of the difference in LOS or charges between these two states. It should be noted that data for this study were collected for hospital admissions from 1984 through 1991 in health care markets that were rapidly changing.

CONCLUSIONS

The mortality rate for SAH in older patients who are treated surgically may be correlated with the annual number of craniotomies performed for SAH in patients 65 years of age or older at a given institution. The mortality rates for SAH in medically and surgically treated older patients do not vary between states, although patients in California are more likely to undergo surgery than individuals in New York. The hospital stay for SAH is significantly shorter, but the costs are not less expensive in California than in New York.

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