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Predicting length of hospital stay and cost by aneurysm grade on admission

J. Paul Elliott, M.D., Peter D. Le Roux, MB., Ch.B., M.D., Galen Ransom, David W. Newell, M.D., M. Sean Grady, M.D., and H. Richard Winn, M.D.

Department of Neurological Surgery, University of Washington, Seattle, Washington

To determine the relationship between clinical grade on admission and treatment cost after aneurysm rupture, the authors retrospectively examined the length of hospital stay (LOS) and total hospitalization costs (excluding professional fees) for 543 patients admitted for aneurysm surgery between 1983 and 1993. The overall median LOS was 18 days, with a range of 1 to 165 days. Increased median LOS correlated with Hunt and Hess Grades 0 to IV on admission ($p < 0.001$). Median LOS for Grade V patients was reduced, in part, because of early mortality. Increased treatment cost also correlated with worse admission clinical grade ($p < 0.001$). A significant proportion of total expenditures occurred early in the hospitalization for patients in all clinical grades. Identification of additional factors affecting the cost of aneurysm treatment is indicated to complement treatment outcome studies.

Key Words • aneurysm surgery • grade • length of stay • cost

Since the pioneering outcome studies by Richardson and colleagues[23–25] in the mid-1960s and the subsequent work by Hunt and Hess,[7] there has been an increasing emphasis on outcome prediction for subarachnoid hemorrhage (SAH) and for the management of cerebral aneurysms. Clinical grade on admission is strongly associated with outcome and probably encompasses many reported outcome predictors such as age and the extent of initial hemorrhage.[2,5,6,14,19,26] The search for more accurate outcome predictors and the continued development of more precise outcome-based measures remains important.[29] In addition, economic concerns require a concomitant improvement in methods for assessing and predicting management cost. Length of hospital stay (LOS) provides a reasonable estimate of medical resource utilization and has been emphasized in several recent publications primarily related to cardiac[3,15] and peripheral vascular surgery.[1,22] The relationship between LOS and neurosurgical procedures such as lumbar laminectomy[16] and carotid endarterectomy[4] has received attention recently. In the present study we tested the hypothesis that, in patients suffering aneurysmal SAH, clinical grade on admission would correlate with LOS and cost.

Clinical Material and Methods

Patient Population, Management, and Outcome

All patients with the diagnosis of cerebral aneurysm admitted to Harborview Medical Center at the University of Washington between September 1983 and August 1993 were retrospectively reviewed. Harborview is the Level 1 acute care facility for Seattle and its surrounding area. Subarachnoid hemorrhage from aneurysm rupture was confirmed on admission by computerized tomography (CT) scan (model 9800; General Electric Corp., Milwaukee, WI) or in rare cases by lumbar puncture. Aneurysm location was assessed using four-vessel angiography, or in the case of moribund patients, by infusion CT scanning.[10,18] All patients admitted during this time period were considered to be candidates for surgery and were treated with a standardized regimen that included: 1) aggressive preoperative resuscitation; 2) early surgery; 3) aggressive management of intracranial pressure and vasospasm; and 4) intensive perioperative care in a dedicated neurosurgical intensive care unit (ICU).[10–13] Routine intracranial pressure and invasive hemodynamic monitoring, frequent head and single-photon emission CT scans supplemented the clinical evaluation. Phenytoin to therapeutic levels, dexamethasone, and nimodipine (starting in 1987) were routinely administered. Volume expansion and hemodilution were initiated prophylactically in all patients. Beginning in 1987, daily perioperative transcranial Doppler examinations were performed to diagnose vasospasm, which was subsequently confirmed with angiography. Since 1989, all patients who developed symptomatic medically refractory vasospasm were treated with balloon and/or papaverine angioplasty.[17]

Clinical Grade and Length of Hospital Stay

Hunt and Hess grade[7] was assessed at admission by a member of the neurosurgical team. Changes in grade were not made for systemic disease or the presence of vasospasm. Using a standardized data instrument, we reviewed hospital records and radiographic studies for all patients

TABLE 1

Length of hospital stay for treatment of cerebral aneurysms in relation to Hunt and Hess grade on admission

Hunt & Hess Grade	Length of Stay (days)		
	Median*	Mean	Range
0	10	14	2–54
I	15	18	5–44
II	18	20	1–82
III	23	24	1–86
IV	28	27	3–100
V	16	21	1–165

* $p < 0.001$ (Grades 0–IV).

and abstracted more than 500 data entries per patient from the preoperative, operative, and postoperative periods. The LOS was defined as the number of days a patient received inpatient neurosurgical care during the initial hospitalization. Rehabilitative care was not included in LOS. Total LOS was divided into the number of days in the intensive and nonintensive care units. Overall LOS during the first 5-year period was compared to the second 5-year period.

Cost Analysis

The management cost for patients receiving neurosurgical care for cerebral aneurysms was determined by reviewing computerized institutional financial records using *International Classification of Diseases, Ninth Revision* (ICD.9.CM) codes for unruptured cerebral aneurysm (437.3) and subarachnoid hemorrhage (430).[8] The list of medical records generated was confirmed using our clinical aneurysm database. Total hospital charges for all patients during the 10-year period were subdivided into six categories: room, surgery, radiology, laboratory, pharmacy, and miscellaneous. Hospital charges were used as an approximation of management cost. Professional fees were not included because they were not available on the same computerized database. All figures are reported in US dollars. Where indicated, mean costs have been adjusted for inflation to reflect estimated value in 1995 dollars. Unit charges for a day in the ICU and an hour of operating room time in 1983 were compared to the same charges in 1995. Total patient ICU days and operating room hours were used to derive a weighted estimate reflecting the overall increase in charges during the period from 1983 to 1995. This allowed derivation of a factor reflecting the estimated effective annual compounding rate. Using this factor, the cost for each individual patient was adjusted to 1995 dollars.

Statistical Analysis

Following entry of cost data into the clinical database, statistical analysis was performed using a commercially available software package (SPSS/PC+, Version 4.0; SPSS Inc., Chicago, IL). The median LOS and cost, as well as adjusted mean cost, were tested against clinical grade on admission using the Spearman rank-order correlation. The LOS mean and range, and unadjusted management cost mean and range, were also identified. Length of stay for good-grade (I–III) and poor-grade (IV–V) cohorts during the first 5 years was compared to the final 5 years using the Mann–Whitney U-test.

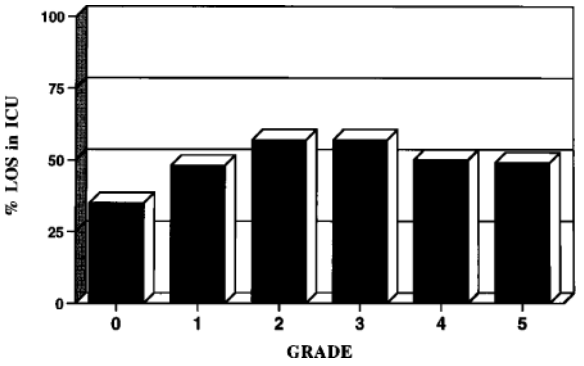

FIG. 1. Bar graph showing length of stay (LOS) in the intensive care unit (ICU) as a percentage of overall LOS according to Hunt and Hess grade on admission: (0) unruptured; (I) asymptomatic or minimal headache or nuchal rigidity; (II) moderate or severe headache, no neurological deficit except cranial nerve palsy; (III) drowsiness, confusion, or mild focal deficit; (IV) early decerebrate rigidity, vegetative disturbance; and (V) coma. No adjustment of grade was made for serious systemic disease or vasospasm.

Results

Clinical Data

During the decade between September 1983 and August 1993, 543 patients (158 male, 385 female) received treatment for cerebral aneurysms. The median age was 51 years, with a range of 5 to 91 years. An unruptured aneurysm was the presenting pathology in 106 cases (20%); after SAH, patients presented with good clinical grade (Hunt and Hess Grades I, II, and III) in 278 (51%) and with poor grade (IV or V) in 159 (29%) of cases. The symptomatic aneurysm was located in the anterior circulation in 434 patients (80%) and in the posterior circulation in 109 patients (20%). Overall, 391 patients (72%) experienced a favorable outcome, defined as "good" or "moderately disabled" on the Glasgow Outcome Scale.[9] A detailed description of clinical aspects and outcome of these patients is reported elsewhere.[10–13]

Length of Stay

Overall, the median LOS was 18 days. The median LOS correlated with admission clinical grade, increasing from 10 days for Hunt and Hess Grade 0 patients to 28 days for Grade IV patients (Spearman correlation 0.24, $p < 0.001$; Table 1). Grade V patients demonstrated a relative decrease in median LOS due to their increased early mortality. Intensive care unit LOS represented between 35% and 57% of total LOS but did not correlate with clinical grade (Fig. 1). Overall, patients suffering SAH remained in the ICU for approximately 50% of their neurosurgical hospitalization.

The median LOS for the study population during the first 5 years was 21 days. This decreased significantly during the second 5 years to 16 days (Mann–Whitney, $p < 0.001$). The median LOS decreased from 22 to 18 days in

TABLE 2

Cost of care for cerebral aneurysms in relation to Hunt and Hess grade on admission

Hunt & Hess Grade	Charges (U.S. $)			
	Median*	Mean	Range	Adjusted Mean†
0	20,797	32,835	4,140–122,004	52,064
I	26,058	40,928	8,634–104,650	65,949
II	60,749	52,144	5,225–133,984	83,232
III	75,595	56,063	5,873–175,027	99,369
IV	97,679	63,440	11,705–197,941	108,690
V	75,168	50,280	4,993–227,105	96,194

* $p < 0.001$ (Grades I–IV).
† Mean charges adjusted for inflation to 1995 dollars.

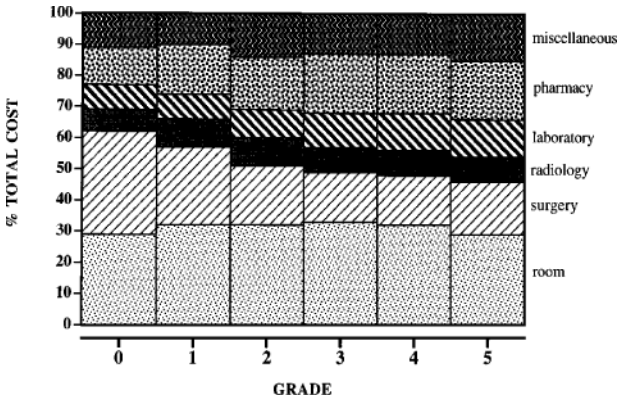

FIG. 2. Bar graph showing breakdown of hospital charges for aneurysm surgery by Hunt and Hess grade on admission.

good-grade patients ($p < 0.021$) and decreased from 29 to 22 days in poor-grade patients ($p < 0.042$).

Cost Analysis

The median unadjusted total hospital charges (excluding professional fees) correlated with clinical grade on admission and increased from approximately $21,000 for patients receiving care for unruptured aneurysms to approximately $98,000 for patients who suffered Grade IV SAH ($p < 0.001$, Table 2). The median cost of care for patients who were Grade V at admission, however, decreased and was similar to the cost for patients who were Grade III at admission. The mean charge and range of charges also correlated with Grades 0 to IV. The distribution of charges, however, was similar among grades, with room and surgical charges accounting for the majority of the overall cost (Fig. 2). Following adjustment of charges for inflation to 1995 dollars, the correlation between clinical grade on admission and treatment charges persisted (Table 2).

Discussion

In the present study, we document that for patients with ruptured or unruptured aneurysms (Grades 0–IV), clinical grade on admission correlates with both neurosurgical LOS and total hospital charges. Patients in the worst clinical grade (V), however, demonstrated a relative reduction in both LOS and cost. Although this is the first such observation relating clinical grade on admission with LOS and cost for patients receiving treatment for cerebral aneurysms, the association between LOS and severity of disease has been described in other disorders. For example, in heart transplant recipients, Grady, *et al.*,[3] noted that worse preoperative heart failure was associated with increased LOS. These investigators stressed the need for further evaluation of how preoperative and postoperative factors, particularly medical and nursing interventions, influence LOS.

The association of increased LOS and cost of treatment of patients following cerebral aneurysm surgery parallels findings in other diseases. For example, Breckwoldt, *et al.*,[1] observed a correlation between LOS and total standard costs for repair of abdominal aortic aneurysms. However, these investigators were not able to predict clinical outliers who accounted for the majority of institutional financial losses. The authors therefore recommended revision of the diagnostic-related group system to allow for the increased LOS necessary for the treatment of complex illnesses in high-risk patients. Increased LOS was also found to be the most important factor associated with institutional financial loss following the repair of thoracoabdominal aneurysms.[22] In the present study, we documented that 50% or more of the total costs for patients with a ruptured or unruptured cerebral aneurysm were associated with surgery and LOS in intensive care.

Numerous investigators have identified the decreased morbidity and mortality associated with repair of unruptured aneurysms when compared to treatment of patients with ruptured aneurysms.[21,27,28,31] Our results document the decreased LOS and cost associated with the treatment of patients with unruptured aneurysms and suggest that repair of aneurysms prior to rupture could represent significant savings in public health expenses and utilization of neurosurgical resources. These findings are consistent with recent observations by Wiebers, *et al.*,[30] who estimated direct costs for patients with SAH hospitalized in the United States to be 1.5-fold greater than for patients with unruptured aneurysms. The cost savings for the treatment of unruptured aneurysms, however, will need to be considered in conjunction with the cost of screening programs.[20]

In summary, Hunt and Hess grade, which is easily and reliably determined at hospital admission, correlates with both LOS and cost for patients undergoing treatment of cerebral aneurysms. Clinical grade on admission, therefore, will be useful when considering the global issues of hospital resource management. Further precision will be derived from continued efforts to identify clinical, radiographic, and treatment factors that will allow a more specific prediction of individual LOS and cost of treatment. Because a large proportion of treatment costs occur early in the course of aneurysm management, it remains particularly important to identify factors that might allow reduced perioperative LOS in the ICU without jeopardizing outcome.

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Address for Dr. Le Roux: New York University Medical Center, New York, New York.
Address reprint requests to: H. Richard Winn, M.D., Department of Neurological Surgery, Harborview Medical Center, University of Washington, 325 Ninth Avenue, Seattle, Washington 98104.