THERE is a general sense of futility when treating patients with spontaneous ICH. Despite improvements in neurological intensive care, and concerns that ICH outcome may be worsened by physician pessimism, the fact remains that less than one-third of patients with ICH make a good functional recovery. Within 30 days of the ICH ictus, 35–52% of patients are likely to die, and only 20% are expected to be functionally independent at 6 months. Worst of all, there is no proven effective treatment for this disease other than supportive measures; clinical trials have consistently failed to identify a role for surgery in the treatment of ICH. In 1999, a special writing committee appointed by the American Heart Association issued treatment guidelines for ICH based on 5 small randomized clinical trials of medical treatment and 4 small randomized clinical trials of surgery. These guidelines were recently updated in 2007, incorporating the findings of 15 other recent controlled studies of ICH treatment. However, based on the evidence available in the literature, it has not been possible for the special committee to issue even a single Class I (Strength of Evidence Level “A”) ICH-specific treatment recommendation in the updated guidelines.

Object. Recently updated guidelines failed to reflect significant progress in the treatment of intracerebral hemorrhage (ICH). Using data from a nationwide hospital database, the authors identified recent trends in therapy and outcomes for ICH, as well as the effect of associated comorbidities and procedures, including surgery.

Methods. Data from the Nationwide Inpatient Sample hospital discharge database (Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality) for the period 1993–2005 was retrospectively reviewed. Multiple variables were categorized and subjected to statistical analysis for codes related to ICH from the International Classification of Diseases, 9th revision, Clinical Modification. Data linked by the Nationwide Inpatient Sample database to associated diagnoses and procedures were also retrieved and analyzed.

Results. The number of discharges remained constant for ICH. The mortality rate remained unchanged at an average of 31.6%, whereas routine discharges (home) steadily declined by 25%, and discharges other than home doubled (p < 0.01). By the end of the study, length of hospital stay decreased by 30% (p < 0.01), and mean hospital charges steadily increased to more than twice the original figures. Arterial hypertension was the most frequently associated comorbidity. Seizures were associated with longer hospital stays and higher mean hospital charges. Craniotomy was associated with decreased mortality rates but also with worse outcomes and lower rates of patients discharged home (p < 0.01). No geographic differences in treatment and outcomes were noted.

Conclusions. From 1993 to 2005, no significant progress in treatment and prevention of ICH was noted. There were no regional differences in the treatment and outcome of ICH. The role of surgery for ICH remains uncertain, and large-scale controlled studies are greatly needed to clarify this role. (DOI: 10.3171/2008.5.17559)
trends in demographics and therapy for spontaneous ICH in the US.

Methods

To delineate these trends for spontaneous ICH, the NIS database from the HCUP (sponsored by the Agency for Healthcare Research and Quality) was reviewed. The NIS database is the largest of the all-payer inpatient care databases in the US. The data includes 100% of all discharges from a stratified random sample of nonfederal hospitals in 19–28 states. Thus, a representative 20% subsample of the entire US was included in these hospital discharges, equating to ~8 million hospital stays from 1000 hospitals. The NIS is one in a family of databases and software tools developed as part of the HCUP. These data are available on the Internet at the HCUP website (HCUPnet; http://hcupnet.ahrq.gov/). The HCUPnet generates statistics using data from HCUP’s NIS database, Kids’ Inpatient database, and State Inpatient databases for those states that have agreed to participate. The HCUPnet also provides statistics based on Agency for Healthcare Research and Quality patient safety indicators that have been applied to the NIS and includes a “Quick Statistics” option that provides ready-to-use tables with commonly requested information. Data from HCUPnet are available beginning with the year 1997, and trend information is available beginning with the year 1993.

Trend data were therefore obtained from the NIS for the period 1993–2005, the earliest and latest years of available data at the time of the study. Categorized data were available from 1997–2005. Associated diagnoses and associated procedures data linked by the NIS to the primary diagnosis (ICH) was available from 2001–2005. Discharge data were retrieved by searching principal diagnoses and procedures as listed in the ICD-9-CM. Following the search strategy previously used by ourselves and others, the following codes were used for data query: 431.0 (ICH) and 432.9 (ICH, nontraumatic, not otherwise specified). Trend data were obtained using the software provided by the NIS and downloaded to a spreadsheet (Excel, Microsoft Corp.). Separate tables were assembled for analysis of categorized data from 1997–2005. The attributes considered for analysis included: hospital teaching status, hospital location (metropolitan vs nonmetropolitan), US region (Northeast, Midwest, West, and South), patient age group (<1 year, 1–17 years, 18–44 years, 45–64 years, 65–84 years, and ≥85 years), and sex (male or female). Tables for associated diagnoses and procedures from 2001–2005 were also assembled based on data provided by the NIS. The data for associated ICD-9-CM diagnostic codes available for analysis included: arterial hypertension (401.9), atrial fibrillation (427.31), diabetes mellitus (250), seizures (780.39), urinary tract infection (599), coronary artery disease (414), obstructive hydrocephalus (331.4), COPD (496), aspiration pneumonia (507), and dysphagia (787.2). The data for associated procedural codes (ICD-9-CM) available for analysis included: craniotomy (1.39 = other brain incision, 1.24 = other craniotomy, 1.59 = other brain excision, 1.31 = incise cerebral meninges), ventriculostomy (2.2 = ventriculostomy, 2.39 = other ventricular shunt), cerebral angiography (88.41), tracheostomy (31.1), percutaneous enterostomy (43.11), interruption of vena cava (38.7), transfusion of blood elements (99.04, 99.05, 99.07), and mechanical ventilation to exceed 96 hours (96.72). The outcome measures considered included: inhospital death, routine discharge (used as a surrogate indicator of good outcome), discharge other than routine (used as a surrogate indicator of morbidity), LOS, and mean hospital charges. The definitions of data categories are summarized in the Appendix. Graphs were constructed for trend analysis and comparison of outcomes based on selected categories. Statistical analysis was performed using the chi-square test with Yates’ correction.

Results

Using the search strategy described above, data from 905,152 patients were accrued for review.

Trend Analysis

The results of our trend analysis indicated that the number of discharges exhibited a steady increase that peaked in 1998 and then gradually reversed the trend to values similar to those found at the beginning of the study period (Table 1). Considering a 1% yearly increase in the general population for the period (US Census Bureau Population Estimates; http://www.census.gov/popest/estimates.php, accessed February 6, 2008), no significant differences in the incidence of ICH was found. The figures obtained in our study are in concordance with those reported more recently, a much higher incidence of ICH than the typically cited incidence of 37,000/year. Mortality rates remained virtually unchanged at an average of 31.6% (Fig. 2). Routine discharges steadily declined by almost 25% (p < 0.01; Fig. 3), whereas discharges other than home doubled by the end of the study period (p < 0.01; Fig. 4). By the end of the trend study, length of hospital stay had decreased by 30% (p < 0.01), and mean hospital charges steadily increased to more than twice the original figures. After adjusting for the cost of living increase (35% from 1993–2005), the mean hospital charges had increased by 61.2% (Fig. 5). Aggregate charges (the “national bill”) grew from $1,606,101,346 in 1993 to $2,914,239,142 in 2005. Considering a 35% increase in the cost of living throughout the study period, this increase represents a real increment of 25.6% (Table 1).

Analysis by Category

Incidences of ICH were consistently higher for the age group 65–84 years, which included half the discharges throughout the study period. Increasing age was associated with significantly increased death and discharge other than routine (p < 0.01). Length of hospitalization and mean hospital charges were significantly higher in younger patients. Conversely, younger age was associated with higher incidences of routine discharges. There were no significant disparities in sex distribution (male:female ratio = 1:1.06). Male sex was associated with significantly longer hospital stays, mean hospital charges, and routine discharges (p < 0.01). In contrast, female sex was asso-
associated with a higher incidence of discharge other than home. There were no significant differences in mortality rates between the sexes.

Metropolitan hospitals were the treatment facilities for ~ 90% of ICH discharges. Patients in these hospitals exhibited longer hospital stays, higher mean hospital charges, lower mortality rates, and higher rates of discharged home (p < 0.01). When scrutinizing the workload share of ICH by hospital teaching status, there were no significant differences in the number of patients treated, with a slightly higher number of discharges at teaching hospitals. Teaching hospitals were associated with significantly longer hospital stays, mean hospital charges, and routine discharges, whereas nonteaching hospitals demonstrated statistically significant higher rates of mortality and discharges other than home (p < 0.01). Teaching status and larger hospital size were associated with significantly higher hospital charges and longer hospital stays and with significantly better outcomes and lower mortality rates (p < 0.01). An analysis of discharges by geographic region revealed that the majority of discharges occurred in the South, followed by the Midwest, the West, and the Northeast. Mortality rates showed no statistically significant differences according to geographic region but were slightly higher in the Northeast. Routine discharge rates were slightly higher in the South (a nonstatistically significant finding), mean hospital charges were higher in the West, and discharges other than routine were higher in the Northeast. No analysis on mean hospital charges was undertaken due to the inability to match economic data among regions.

**Associated Diagnoses**

Analysis of the associated diagnoses linked by the NIS to ICH revealed that arterial hypertension was the most prevalent comorbidity, affecting ~ 60% of the discharges. The coexistence of arterial hypertension did not have an effect on any of the outcome measures. The second most prevalent associated diagnosis in this set of data was atrial fibrillation, which affected an average of 16% of discharges and had no effect on outcomes. Other available associated diagnoses without influence on outcome measures included diabetes mellitus (15.3%), coronary artery disease (9.3%), and COPD (7.3%).

Among those associated diagnoses with an influence on outcome measures, seizures (average 19.4% prevalence) were associated with statistically significant longer hospital stays and higher mean hospital charges. Mortality rates, in contrast, were significantly lower (p < 0.01) in those patients with seizures. Aspiration pneumonia, linked to almost 6% of the discharges in this patient series, was the associated diagnosis that was correlated with the longest hospital stays (average 14 days) and highest mean hospital charges (p < 0.01). Higher mortality rates and discharges other than home were also linked to this diagnosis (p < 0.01). Urinary tract infections (12%) and swallowing disturbances (7%) were similarly associated with longer hospital stays, higher mean hospital charges, and more discharges other than home (p < 0.01). Inhospital mortality rates were conversely significantly lower for these 2 comorbidities. Among all listed associated diagnoses, obstructive hydrocephalus was associated with the highest mortality rate (average 47.6%; p < 0.001). Hospital LOS and mean hospital charges were also significantly higher for this group, whereas routine discharges for these patients were the lowest in this series.

**Associated Procedures**

The most commonly associated procedure in this series was craniotomy, with an average of 5.87%. In this group with craniotomy, mortality rates were a statistically significant 14% lower (Fig. 6) and routine discharges were significantly lower (p < 0.01; Fig. 7), but discharges other than routine were significantly higher (p < 0.01; Fig. 8). Hospital stays doubled and mean hospital charges tripled for ICH discharges with concomitant craniotomy (Fig. 9). A similar profile in terms of mean hospital charges and hospital LOS was identified with the association of ventriculostomy (3.7% of ICH discharges). In contrast to mortality rates in patients with craniotomy, mortality rates were the highest in patients with ventriculostomy (average 51%; p < 0.01).

Among all listed associated procedures, tracheostomy was associated with the longest hospitalizations (average 33.7 days; p < 0.001), and the highest rate of discharges other than home and mean hospital charges (p < 0.01). Interruption of the vena cava and percutaneous enterostomy had a similar outcome profile. Cerebral angiography and transfusion of blood products did not have any significant effect on outcome measures. Two-thirds of the patients who underwent continuous mechanical ventilation for > 96 hours died.
Discussion

The results of our study reflect a lack of progress in the treatment and prevention of ICH in more than a decade. Almost one-third of patients diagnosed with ICH died while in the hospital, and patients discharged home (used as a surrogate indicator for good outcome) steadily declined throughout the study period. By 2005, only 1 of every 5 patients with ICH was discharged home. Conversely, discharges other than home (used as a surrogate indicator of morbidity) steadily increased to a rate > 50% by the end of the study period, although it could be argued that this increase is possibly related to tighter cost utility analysis implemented in the mid-90s. Mean hospital charges during the study period had increased by > 60% after adjustment for cost of living, even though hospital LOS declined by 30%. The overall results are clearly disappointing and in blatant contrast with those of the recent widely publicized report by the American Heart Association that announced a stroke age-adjusted death rate decrease by 24.4%.

The overall results across the different US regions were solidly homogeneous, suggesting no significant differences in terms of demographics or treatment strategies across the nation. Breakdown of the data into different categories, as allowed by the NIS data availability, did not reveal any surprising findings: younger patients fared better at a higher cost, whereas increasing age was associated with higher prevalence of ICH and more deaths and morbidity. Hospital teaching status was associated with statistically significant better outcomes and lower inhospital mortality rates, but also with statistically significant longer hospital stays and mean hospital charges.

When considering associated diagnoses reported in conjunction with ICH diagnostic ICD-9-CM codes, arterial hypertension was the most frequently associated comorbidity, followed by atrial fibrillation, diabetes mellitus, coronary artery disease, and COPD. None of the latter comorbidities had any effect on outcome measures. Among those comorbidities with an effect on patient outcome, seizures, with an almost 20% incidence, resulted in statistically significant longer hospital stays and mean hospital charges. This was perhaps the only significant finding in our analysis of associated comorbidities. Other comorbidities, such as urinary tract infection, aspiration pneumonia, and dysphagia had an effect on ICH outcome. However, they could also be interpreted as indicators of survival and chronic state based on their association with longer hospitalization, lower mortality rates, and higher rates of discharge other than home. Their undeniable effect resides, though, on significantly increased mean hospital charges.

Obstructive hydrocephalus was fatal in almost half of the patients who had this associated diagnosis, and it was associated with the lowest incidence of good outcomes in
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this cohort. This finding is in agreement with data from Diringer et al.\textsuperscript{14} who found a hospital mortality rate of 51\% in patients with hydrocephalus. Disappointingly, no meaningful data were linked in the database in connection with anticoagulant use and ICH.

Only 5.87\% of patients in this sample of > 900,000 discharges were treated with surgery for evacuation of ICH. Although mortality rates were lower in patients with ICH who received surgical treatment (p < 0.01; Fig. 6), good outcomes were lower and morbidity was higher (p < 0.01; Fig. 7). Length of stay and mean hospital charges in this group doubled and tripled, respectively, when compared with the mean overall figures (p < 0.01; Fig. 9). Conversely, use of a ventriculostomy, while presenting a similar profile as use of a craniotomy in terms of charges and hospital stays, was associated with a 51\% mortality rate. Tracheostomy, IVC, and percutaneous enterostomy were also interpreted as markers of chronic state and survival in morbid state, and were associated with longer hospital stays and higher mean hospital charges. Two-thirds of patients who underwent mechanical ventilation for > 4 days died while in the hospital.

The results of this study may not be surprising but are certainly concerning. Few areas for intervention to decrease these disappointing results could be proposed based on the information presented above. Arterial hypertension, a proven independent risk factor for ICH,\textsuperscript{21,38,39} had a prevalence of 60\% in this study, presenting itself as a potential target for intervention as a means of prevention. Treatment of hypertension has been demonstrated to be the most important factor in reducing the incidence of stroke.\textsuperscript{35} A population-attributable risk of 0.22 (odds ratio 2.6, 95\% confidence interval 0.17–0.28) has been recently estimated for untreated hypertension, which implies that 17–28\% of all hemorrhagic strokes among hypertensive individuals could have been prevented by using antihypertensives.\textsuperscript{38}

The data in relation to seizures associated with ICH in our study also brings up the controversy of whether to institute standard seizure prophylaxis based on the significantly higher mean hospital charges and LOS. It could be argued that seizures may represent a marker of severity. However, this particular group had better outcomes when compared with the overall population. Current guidelines contemplate seizure treatment only for patients with ICH and clinical seizures (Class I, Strength of Evidence Level “B”).\textsuperscript{8} However, recent evidence suggests a rate of seizures as high as 28\% in patients with ICH who routinely received continuous electroencephalography monitoring.\textsuperscript{8,31,37} Whether routine seizure prophylaxis outweighs the current recommendation for treatment of clinical seizures only should be addressed in a clinical trial.
Finally, the yet more controversial issue of whether to operate or not for ICH is presented here. In this cohort, only ~6% of patients received surgical treatment, a rate much lower than that reported in international studies, suggesting a generalized lack of belief in surgery as a treatment for ICH. Patients who underwent surgical treatment for ICH demonstrated a statistically significant lower incidence of mortality but higher incidences of discharges other than routine and lower incidences of routine discharges when compared with the mean study population. Whether the decrease in mortality rates had a meaningful effect on the quality of life of those who survived ICH with the aid of surgery cannot be answered with the available data and has been the elusive answer in several recent clinical trials.

Interestingly, the findings of our study in terms of surgical results are similar to those reported in the STICH trial, which found neither benefit nor detriment from surgery for patients with ICH. However, detailed analysis of the patient population in the STICH trial has shown that 42% of patients included in this trial also had an associated IVH, which is known to carry a much worse prognosis (STICH II Trial; http://www.ncl.ac.uk/stich/, accessed February 20, 2008). A post hoc analysis of the STICH data excluding patients with IVH and focusing on superficial hematomas found a statistically significant benefit for surgical patients with lobar ICH within 1 cm from the surface. These findings represent the testing hypothesis of the ongoing STICH II trial (http://www.ncl.ac.uk/stich/, accessed February 20, 2008), and also lend support to what has been referred to as the patient-adapted treatment concept in ICH. In that direction, 2 other ongoing trials, the Minimally Invasive Surgery plus Tissue-Plasminogen Activator for Intracerebral Hemorrhage Evacuation trial (MISTIE trial; http://mistietrial.com/default.aspx, accessed February 20, 2008) and the CLEAR IVH trial (http://clearivh.com/default.aspx, accessed February 20, 2008) are targeting subsets of patients with ICH and their response to surgical treatment. In summary, as suggested from the recent literature, there may be a role for surgery in the treatment of lobar ICH within 1 cm from the surface, and patients with deep-seated ICH could benefit from a combination of stereotactic aspiration aided by pharmacological clot lysis (CLEAR IVH Trial; http://clearivh.com/default.aspx, accessed February 20, 2008). Hopefully, the results of these more selective studies will help determine the proper place for surgery in the treatment of ICH.

In this observational study, we attempted to delineate trends in the treatment of spontaneous ICH in the US, based on discharge data obtained from the largest all-payer inpatient care database in the US. The purpose of this study was to provide a glimpse of recent trends on treatment of spontaneous ICH and the overall measurable results associated with these management strategies in the US in general. It is not our purpose to replace the current lack of rigorously collected data from controlled studies with these figures collected from coded discharge summaries, but rather to bring a snapshot of what has occurred to average patients with spontaneous ICH at average hospitals across the US.

The validity of the data provided by the NIS, which relies purely on ICD-9-CM codes, has been questioned before. However, despite coding errors and limited clinical data availability that do not appear to statistically affect overall results, the NIS has positioned itself as the standard tool for research of large samples of patients. As of the date of completion of this study, 77 published studies were identified that contained data analysis from the NIS in several medical specialties, including neurosurgery. Furthermore, familiarization with these kinds of data is likely to be required in the future for neurosurgeons in light of evolving strategies in health policymaking and reimbursement (pay for performance).

In summary, the results of our study lend support to a generally perceived sense of worthlessness when treating patients with spontaneous ICH. Our findings reveal the significant gap in the progress of treatment and prevention of ICH when compared with other cerebrovascular diseases, such as ischemic stroke and subarachnoid hemorrhage. However, thorough scrutiny of data subsets suggests possible targets for intervention. Similar efforts to those invested in other cerebrovascular diseases in which significant progress has occurred, such as in ischemic stroke, will hopefully bring some promise for advancement in the treatment of ICH. Finally, this study also portrays the monumental costs associated with the treatment of ICH, especially for those who survive with significant disability.

Conclusions

Trend analysis revealed no changes in the demographics, treatment strategies, or outcomes of ICH in more than a decade. Controlled clinical studies are greatly needed to investigate current and potential preventive and therapeutic interventions in an effort to reduce the multifaceted burden of ICH.

Appendix

Language definitions from the HCUP database:

**Hospital discharge** is the unit of analysis for HCUP data (the hospital stay), not a person or patient. This means that a person who...
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is admitted to the hospital multiple times in 1 year will be counted each time as a separate discharge from the hospital.

Hospital charges is the amount the hospital charged for the entire hospital stay. It does not include professional (M.D.) fees. Charges will reflect the total hospital charge, not the charge for that procedure.

Length of stay is the number of nights the patient remained in the hospital for this stay.

Died generally indicates an inhospital death. Some unknown number of patients may have died outside the hospital but are still included in HCUPnet.

Discharge status indicates the disposition of the patient at discharge from the hospital, for example, routine (home), to another short-term hospital, to a nursing home, to home health care, or against medical advice.

Patient age in years was calculated on the basis of the admission date to the hospital.

Sex is coded as male or female.

Teaching status indicates whether the hospital in which the stay occurred is a teaching or a nonteaching hospital. A hospital is considered to be a teaching hospital if the American Hospital Association Annual Survey indicates it has an American Medical Association–approved residency program, is a member of the Council of Teaching Hospitals, or has a ratio of full-time equivalent interns and residents to beds of 0.25 or higher.

Disclaimer

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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