Cost of Spontaneous Intracerebral Hemorrhage in Canada During 1 Decade

Adrian V. Specogna, MSc, PhD; Scott B. Patten, MD, PhD; Tanvir C. Turin, MBBS, MS, PhD; Michael D. Hill, MD, MSc

Background and Purpose—Spontaneous intracerebral hemorrhage (ICH) is widely considered to be the most devastating form of stroke in North America. Currently there is no clear understanding of the cost of treatment in Canada and thus no way of understanding how to manage ICH spending in this country.

Methods—We used a cohort study design to report and to examine the cost of ICH hospital care in a Canadian health center during 1 decade. Economic, treatment, and patients data were obtained from clinical and administrative sources.

Results—Analyses were performed using 987 consecutive patients with ICH from 1999 to 2008. The total inflation-adjusted cost of care was highly variable (median cost per discharge, $10,544.45 and $363.54 [min] to $265,470.43 [max] United States Dollars). Total cost did not change significantly during the decade. Patients age (cost change per year older, −$114.06 and −$189.01 to −$38.78) and in-hospital mortality (cost change for death, −$5092.84 and −$6270.65 to −$3697.09) were significantly associated with lower cost, whereas Charlson Comorbidity Index (cost change for ≥1, −$726.27 and $3965.36 to $7755.45), having surgery (cost change for surgery, $25,499.78 and $20,813.95 to $30,933.06), and admission National Institutes of Health Stroke Scale (cost change for ≥15 points, $7800.20 and $1637.78 to $17,026.38) were significantly associated with higher cost.

Conclusions—to our knowledge, this is the most thorough published study to date to report and to examine predictors of ICH treatment costs in Canada. This study provides evidence that it may be reasonable to consider patients age, probability of death, level of comorbidity, need for surgery, and baseline ICH severity when forecasting health spending.

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Key Words: Canada ■ cerebral hemorrhage ■ economics

Spontaneous intracerebral hemorrhage (ICH) is widely considered to be the most devastating form of stroke, imposing significant burden on society. Several studies have provided ICH cost estimates for various countries. Previous acute care estimates have ranged from as low as $1870 United States Dollars per visit in China to $23,800 United States Dollars per visit in the United States. This study fills a major gap in the literature by providing the most thorough report of ICH treatment costs in Canada. This study provides evidence that it may be reasonable to consider patients age, probability of death, level of comorbidity, need for surgery, and baseline ICH severity when forecasting health spending.

Methods

We used a cohort study design to examine the economic cost of ICH hospital care within 1 Canadian hospital between 1999 and 2008 (inclusive). Our center treats 99% of all ICH cases within our city, which has a population of ≈1 million people overall and is 1 of 2 dedicated stroke centers in our province. In Canada, patient care and hospitalization costs are paid under a universal provincial healthcare plan that is funded from taxation revenue. The cost of care was estimated from the time of admission to the time of discharge and included both direct and indirect expenditures. All adult (≥18 years)-hospitalized patients with a Most Responsible Diagnosis of ICH (International Classification of Diseases-Ninth Revision-Clinical Modification [ICD-9-CM] and ICD-10: 431, I60.0–I61.6, I61.8, and I61.9) who were discharged during 1999–2008 were eligible for inclusion and identified using electronic hospital records. The costs associated with these patients were provided by the provincial health costing department and linked to the electronic patient record. Patients were excluded only if the cost of treatment could not be estimated or was not reported to the provincial government.

Financial data were inflated to 2008 using the general Consumer Price Index for our province to adjust for overall economic inflation. Binomial regression was used to investigate the change in treatment and patient characteristics across the decade. Linear regression was used to investigate the association between inflation-adjusted costs, and calendar year, and patients age, sex, in-hospital mortality, Charlson Comorbidity Index (CCI), having surgery, National Institutes of Health Stroke Scale, and Glasgow Coma Scale at admission. The CCI was estimated from ICD codes using a method previously described. All cost data were log transformed, evaluated using robust SEs, and reported in United States Dollars. The study protocol was approved by our university research ethics board.

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This study was previously presented at the 2012 Canadian Stroke Congress where it was highlighted as a “top breakthrough.” Abstracts from this meeting were published in an online-only issue of Stroke in 2012.

The online-only Data Supplement is available with this article at http://stroke.ahajournals.org/lookup/suppl/doi:10.1161/STROKEAHA.113.003276/-/DC1.

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Results

One thousand two patients with ICH were treated at our center from 1999 to 2008. Cost data were not available in 15 patients, thus they were excluded. The characteristics of the 987 patients included in this study are described in Table I in the online-only Data Supplement.

Calendar year was significantly associated with in-hospital mortality, having surgery, and CCI (0 versus ≥1). The proportion of patients who died in hospital declined from 1999 to 2008 (relative risk [RR] for each year later, 0.96; 95% confidence interval [CI], 0.92–0.99), as did the proportion of patients having surgical treatment (RR for each year later, 0.91; 95% CI, 0.87–0.95) and the overall degree of comorbidity (CCI; RR for each year later, 0.98; 95% CI, 0.96–0.99).

The inflation-adjusted cost of ICH hospital care is presented in Table II in the online-only Data Supplement. The total cost of care did not change significantly from 1999 to 2008; however, some component costs did change. The cost of diagnostics services declined significantly (change in cost per discharge from 1999 to 2008, $−1777.32 to $−1230.98). The cost of surgical services per discharge declined as well, but the real cost decrease was small (<$1 per discharge during the decade) likely because few people (18%) used surgical services overall. These observed reductions in costs are not surprising given the overall decline in comorbidity and use of surgery during this time frame. In contrast, the cost of acute care services increased during the decade (change in cost per discharge from 1999 to 2008, $3256.73; 95% CI, $1075.28 to $6147.02), which was largely driven by the overall increase in nursing costs (change in cost per discharge from 1999 to 2008, $3297.97; 95% CI, $1145.81 to $6148.67).

Patients age, level of comorbidity, in-hospital mortality, having surgery, and ICH severity at admission (National Institutes of Health Stroke Scale) were significantly associated with higher cost in this subgroup, surgery remained the strongest predictor of increased costs (cost increase for those who had surgery in the subgroup, $21109.72; 95% CI, $12018.82 to $33890.21), followed by National Institutes of Health Stroke Scale score at admission.

We reran all analyses among survivors who did not have surgery to investigate the drivers of cost in the majority of patients. All nonsurgical patients with a low Glasgow Coma Scale had died at our center during this time frame, preventing an assessment of cost for this factor. All conclusions remained the same for all other factors except for older age which was significantly associated with higher cost in this subgroup (change in cost per year older among nonsurgical survivors, $45.76; 95% CI, $16.19 to $75.47).

Discussion

The results of this study suggest that the cost to treat ICH in a Canadian center is highly variable. Specifically, the median cost at our center was $10544.45 and ranged from as low as $363.54 to $265470.43 per visit. This estimate was lower than a previous report, which examined the hospital cost of cerebrovascular disease overall in Canada for 1 year (average cost per stay in 2004–2005, $12261.61±$18865.73 United States Dollars). Furthermore, the results of our study suggested that the inflation-adjusted cost to treat ICH in a Canadian hospital was not different from 1999 to 2008, which is inconsistent with a previous American study. It is unclear why the cost of care did not change at our center. However, our data suggest

Table. Factors Associated With Total Inflation-Adjusted Hospital Cost in a Canadian Center

<table>
<thead>
<tr>
<th>Factor</th>
<th>Regression Coefficient (95% CI)</th>
<th>Dollar Change in Cost (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (per year)</td>
<td>−0.007 (−0.011 to −0.002)</td>
<td>−$114.06 (−$189.01 to −$38.78)*</td>
</tr>
<tr>
<td>Sex (men vs women)</td>
<td>0.010 (−0.043 to 0.243)</td>
<td>$1087.63 (−$435.34 to $2844.36)</td>
</tr>
<tr>
<td>Charlson Comorbidity Index (0 vs ≥0)</td>
<td>0.562 (0.420 to 0.704)</td>
<td>$5726.27 (−$9965.36 to $7755.45)*</td>
</tr>
<tr>
<td>In-hospital mortality (yes vs no)</td>
<td>−0.516 (−0.686 to −0.346)</td>
<td>$5092.84 (−$6270.65 to −$3697.09)*</td>
</tr>
<tr>
<td>Surgery (yes vs no)</td>
<td>1.381 (1.233 to 1.529)</td>
<td>$25499.78 (−$20813.95 to $50933.06)*</td>
</tr>
<tr>
<td>NIHSS at baseline (≥15 vs &lt;15)</td>
<td>0.545 (0.142 to 0.949)</td>
<td>$7802.20 (−$16377.78 to $17026.38)*</td>
</tr>
<tr>
<td>GCS at Baseline (≤8 vs &gt;8)</td>
<td>0.209 (−1.291 to 1.708)</td>
<td>$2697.29 (−$8427.19 to $52536.27)</td>
</tr>
</tbody>
</table>

The association between NIHSS (median, 5 [min 0 to max 29]) and GCS (median, 15 [min 3 to max 15]) and cost was estimated from a subgroup of patients (n=195) treated in a dedicated stroke unit. All estimates were derived from linear regression and were unadjusted for patient and treatment characteristics. Costs are reported as 2008 United States Dollars. CI indicates confidence interval; GCS, Glasgow Coma Scale; and NIHSS, National Institutes of Health Stroke Scale.

*Significant (P<0.05).
that the proportion of patients who died in hospital declined during the decade as did the overall level of comorbidity and the use of surgery, which may explain why overall treatment costs were balanced.

Our study demonstrated that the use of surgery may be one of the strongest predictors of higher cost. Given the significantly higher costs for surgery compared with standard medical care, and that the efficacy of surgery remains controversial overall, we suggest that there may be a need for future economic analyses of this intervention. Specifically, the results of this study highlight that the choice to perform surgery may have a substantial effect on opportunity costs for ICH therapy.

The limitation of our study is that we did not evaluate the effect of withdrawal of care decisions and did not have stroke-specific clinical data on all patients. Furthermore, although we attempted to identify patients with spontaneous ICH, we cannot rule out the inclusion of some patients with other forms of intracranial hemorrhage, such as subarachnoid hemorrhage, because of the limitations of administrative data. Finally, we did not specifically examine the effect of stroke physician fees on ICH costs because it was not possible to link patients with specific stroke physicians.

Conclusions

The cost of ICH care in Canada is highly variable. This study provides evidence that it may be reasonable to consider patients age, level of comorbidity, probability of death, need for surgery, and baseline ICH severity when forecasting health spending for stroke.

Sources of Funding

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Disclosures

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References

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Table I. Sample Characteristics. Data are reported as median (min-max) unless otherwise noted.

*Significant (p<0.05) decrease from 1999-2008
†Significant (p<0.05) increase from 1999-2008
### Table II.
The total inflation-adjusted cost per discharge of ICH hospital care from 1999-2008 in a Canadian centre. Data were right-skewed thus are presented as median (min-max) inflated to 2008 United States Dollars. Changes in costs from 1999-2008 were evaluated using linear regression and were unadjusted for changes in patient or treatment characteristics. Some patients may have died prior to accessing diagnostic services or had an ICH diagnosis made at other centres resulting in zero costs for that component.