Hospitalization Costs for Patients With Acute Ischemic Stroke Treated With Endovascular Embolectomy in the United States

Waleed Brinjikji, MD; David F. Kallmes, MD; Alejandro A. Rabinstein, MD; Giuseppe Lanzino, MD; Harry J. Cloft, MD, PhD

Background and Purpose—It is important to know the costs of hospitalization for patients undergoing endovascular embolectomy so that comparisons can be made with payments to hospitals.

Methods—Using the National Inpatient Sample, we evaluated the costs of hospitalization for patients treated with endovascular embolectomy in the United States from 2006 to 2008. The primary end point examined in this study was total hospital costs, and these were correlated with clinical outcome.

Results—A total of 3864 patients received endovascular embolectomy. A total of 1649 patients were ≥65 years old and 2205 patients were <65 years old. Median hospital costs in 2008 dollars were $36,999 (interquartile range, $26,662–$56,405) for patients with good outcome, $50,628 (interquartile range, $33,135–$76,063) for patients with severe disability, and $35,109 (interquartile range, $25,053–$62,621) for patients with mortality.

Conclusions—Hospitalization costs for patients treated with endovascular embolectomy are rather high, probably due to the serious nature of their illness. Medicare payments have not been adequate reimbursement for these hospitalizations. (Stroke. 2011;42:3271-3273.)

Key Words: acute stroke • acute stroke syndromes • emergency treatment of stroke • endovascular treatment • interventional neuroradiology subject codes

The first endovascular clot retrieval device for acute ischemic stroke has become a widely accepted treatment for a select group of patients with acute ischemic stroke. High rates of morbidity and mortality as well as frequent associated complications and comorbidities1 would be expected to result in high financial costs for hospitalization of these patients. Knowing the costs of hospitalization is important for understanding the economic impact of these patients on the hospitals that care for them. We evaluated recent data to determine costs associated with hospitalization for patients with acute ischemic stroke treated with endovascular clot retrieval, including subgroup analysis to determine the effects of age and discharge status on hospital costs.

Methods

Patient Population

The National Inpatient Sample (NIS) is a hospital discharge database that represents 20% of all inpatient admissions to nonfederal hospitals in the United States. Using the NIS for years 2006 to 2008, patients who experienced an ischemic stroke were identified using International Classification of Diseases, 9th Revision codes 433, 434, 436, 437.0, and 437.1. Patients undergoing endovascular clot retrieval were identified using the International Classification of Diseases, 9th Revision procedure code 39.74.

The primary end point examined in this study was hospital costs. Hospital costs were determined by taking the total hospital charges and multiplying them by the mean cost-to-charge ratio for each patient’s hospital. To account for inflation, we used the consumer price index calculator available at http://data.bls.gov/cgi-bin/cpicalc.pl. Charges and costs were converted to their dollar value in 2008. We examined the correlation between the following variables and total costs: age, gender, discharge status (home/short-term facility, long-term facility, and in-hospital death), length of stay, intracranial hemorrhage, gastrointestinal bleeding, mechanical ventilation, gastrostomy, and tracheostomy. Discharge to a long-term facility was used as a surrogate outcome for disability.

Statistical Analysis

For the purposes of statistical analysis, we summed the data from 2006 to 2008. We used the nonparametric Wilcoxon rank-sum test to determine statistical significance. Multivariate analysis to determine predictors of cost and length of stay was performed using a standard least-squares model.

Results

For 2006 to 2008, a total of 3864 patients received endovascular clot retrieval. A total of 1649 (42.7%) patients were <65 years old and 2215 (57.3%) patients were ≥65 years old. A total of 1983 (51.3%) patients were discharged to long-
term facilities, 940 (24.3%) patients experienced in-hospital mortality, and 941 (24.4%) patients were discharged home. Data are summarized in the Table. There was no significant difference in the median costs for patients ≤65 years old when compared with ≥65 years old (P=0.61). Discharge status was significantly correlated with median costs. Patients discharged to home or short-term facilities had significantly lower median costs when compared with those patients discharged to long-term facilities ($36 999 versus $50 628, P=0.0001). Patients with intracranial hemorrhage (P=0.02), and tracheostomy (P=0.0002) had higher costs of hospitalization.

When performing our multivariate model, we found that male gender (P=0.03), longer length of stay (P<0.0001), discharge to a long-term facility (P=0.02), and performance of gastrostomy (P=0.03) were independent predictors of increased hospital costs.

**Discussion**

The 2006 to 2008 median cost of hospitalization for patients treated with endovascular embolectomy was $36 999 for those with a good outcome, which does not compare favorably with the average 2008 Medicare payment of $22 075 for mechanical embolectomy without (MS-DRG 24) major complication (www.cms.hhs.gov). Similarly, the median hospital costs of $50 628 for patients with morbidity and $35 109 for patients with mortality do not compare favorably with the average 2008 Medicare payment of $26 639 for mechanical embolectomy with major complication (MS-DRG 23; www.cms.hhs.gov). For Medicare patients in 2008, hospitals typically lost approximately $15 000 on each patient with a good outcome, $24 000 on each patient with disability, and $9000 on each patient with mortality.

The high cost of caring for these patients is not entirely surprising, because they are often quite ill and caring for them requires many resources. The severity of their illness is demonstrated by their high rate of discharge to a long-term facility and mortality, which were shown to be 51% and 24%, respectively, in NIS patients.1 What is perhaps surprising is that costs are relatively high even for patients who have a good outcome and presumably incur considerably less intensive care costs than patients who have major morbidity.

A study of patients treated from 2001 to 2004 in Arizona showed that hospital costs were 2.2 times higher than Medicare reimbursements for hospitalization of patients treated with intra-arterial stroke therapy.2 Although the Medicare payment mechanism for patients undergoing endovascular

### Table. Costs and Length of Stay for Endovascular Embolectomy

<table>
<thead>
<tr>
<th>Variable</th>
<th>Hospital Costs (2008 US Dollars)</th>
<th>Length of Stay (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median (IQR)</td>
<td>Median (IQR)</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>44 231 (79 873–193 759)</td>
<td>8 (4–14)</td>
</tr>
<tr>
<td>Female</td>
<td>40 200 (28 727–63 730)</td>
<td>8 (4–13)</td>
</tr>
<tr>
<td><strong>Age, y</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;65</td>
<td>43 195 (30 070–66 593)</td>
<td>8 (4–14)</td>
</tr>
<tr>
<td>≥65</td>
<td>40 899 (28 901–71 587)</td>
<td>8 (4–14)</td>
</tr>
<tr>
<td><strong>Discharge status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home/short-term facility</td>
<td>36 999 (26 662–56 405)</td>
<td>6 (4–11)</td>
</tr>
<tr>
<td>Long-term facility</td>
<td>50 628 (33 135–76 063)</td>
<td>11 (7–16)</td>
</tr>
<tr>
<td>Dead</td>
<td>35 109 (25 053–62 621)</td>
<td>4 (2–7)</td>
</tr>
<tr>
<td><strong>Intracranial hemorrhage</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>44 523 (32 565–74 935)</td>
<td>10 (4–19)</td>
</tr>
<tr>
<td>No</td>
<td>40 899 (29 040–67 572)</td>
<td>8 (4–13)</td>
</tr>
<tr>
<td><strong>Gastrointestinal bleeding</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>53 769 (37 128–101 323)</td>
<td>13 (9–20)</td>
</tr>
<tr>
<td>No</td>
<td>41 551 (29 197–68 439)</td>
<td>8 (4–14)</td>
</tr>
<tr>
<td><strong>Mechanical ventilation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>50 489 (75 967–152 812)</td>
<td>7 (4–12)</td>
</tr>
<tr>
<td>No</td>
<td>38 437 (28 035–62 717)</td>
<td>10 (4–17)</td>
</tr>
<tr>
<td><strong>Gastrostomy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>53 196 (34 318–73 565)</td>
<td>10 (6–19)</td>
</tr>
<tr>
<td>No</td>
<td>40 640 (29 050–67 685)</td>
<td>8 (4–13)</td>
</tr>
<tr>
<td><strong>Tracheostomy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>55 490 (40 658–103 761)</td>
<td>11 (4–13)</td>
</tr>
<tr>
<td>No</td>
<td>40 712 (29 021–67 032)</td>
<td>8 (5–21)</td>
</tr>
</tbody>
</table>

IQR indicates interquartile range.
Embolectomy has evolved substantially since the time of that study, our study using the NIS indicates that underreimbursement continues.

The high charges in hospitalizations for endovascular embolectomy should not be interpreted to be due primarily to the cost of the embolectomy procedure itself. In fact, one might expect that without endovascular embolectomy, even more patients would be disabled and thus incur even higher hospital costs. It is not possible to identify within the NIS ischemic strokes of similar severity that were not treated by endovascular embolectomy, so we cannot assess hospital charges for such a cohort. Outcomes tend to be better with endovascular recanalization with reduced death and higher percentage with little or no disability, so it is quite possible that costs associated with hospitalization will be compensated later by decreases in long-term costs.

Coding errors are a potential limitation of this study as they are with any study of a large administrative database.

Our study of the NIS shows that hospitalization costs in the United States for patients with ischemic stroke treated with endovascular embolectomy are rather high, probably due to the serious nature of their illness. Medicare payments have not been adequate in reimbursing these hospitalizations. Further work is needed to ensure the future reconciliation of costs with payments.

**Disclosures**

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**References**

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