US Geographic Distribution of rt-PA Utilization by Hospital for Acute Ischemic Stroke

Dawn Kleindorfer, MD; Yingying Xu; Charles J. Moomaw, PhD; Pooja Khatri, MD; Opeolu Adeoye, MD; Richard Hornung, PhD

Background and Purpose—Previously, we have estimated US national rates of recombinant tissue plasminogen activator (rt-PA) use to be 1.8% to 3.0% of all ischemic stroke patients. However, we hypothesized that the rate of rt-PA use may vary widely depending on regional variation, and that a large percentage of the US population likely does not have access to hospitals using rt-PA regularly. We describe the US geographic distribution of hospitals using rt-PA for acute ischemic stroke.

Method—This analysis used the MEDPAR database, which is a claims-based dataset that contains every fee-for-service Medicare-eligible hospital discharge in the US. Cases potentially eligible for rt-PA treatment based on diagnosis were defined as those with a hospital DRG code of 14, 15, or 559, and that also had an ICD-9 code of 433, 434, or 436. Thrombolysis use was defined as an ICD-9 code of 99.1. Study interval was July 1, 2005 to June 30, 2007. Hospital locations were mapped using ArcView software; population densities and regions of the US are based on US Census 2000.

Results—There were 4750 hospitals in the MEDPAR database, which included 495 186 ischemic stroke admissions during the study period. Of these hospitals, 64% had no reported treatments with rt-PA for ischemic stroke, and 0.9% reported >10% treatment rates within the MEDPAR dataset. Bed size, rural or underserved designation, and population density were significantly associated with reported rt-PA treatment rates, and remained significant in the multivariable regression. Approximately 162 million US citizens reside in counties containing a hospital reporting a ≥2.4% treatment rate within the MEDPAR dataset.

Conclusion—We report the first description of US hospital rt-PA treatment rates by hospital. Unfortunately, we found that 64% of US hospitals did not report giving rt-PA at all within the MEDPAR database within a 2-year period. These tended to be hospitals that were smaller (average bed size of 95), located in less densely populated areas, or located in the South or Midwest. In addition, 40% of the US population resides in counties without a hospital that administered rt-PA to at least 2.4% of ischemic stroke patients, although distinguishing transferred patients is problematic within administrative datasets. Such national-based resource-utilization data is important for planning at the local and national level, especially for such initiatives as telemedicine, to reach underserved areas.

Key Words: acute care ■ acute stroke ■ epidemiology ■ stroke care ■ stroke recovery ■ tPA ■ treatment

Recombinant tissue plasminogen activator (rt-PA) was approved by the FDA in 1996 for the treatment of acute ischemic stroke.1 Despite its proven efficacy, however, rt-PA therapy has not been widely used among ischemic stroke patients. Studies have estimated that only 1.8% to 3.0% of all ischemic stroke patients in the United States are treated with rt-PA2-4; the upper end of that range was not achieved until FY 2007. There are many reasons why rt-PA is not administered to more stroke patients, the most important of which is prehospital delays in presentation.4 Within the US population, only 8% of ischemic stroke patients present to an emergency department eligible for rt-PA.5 In addition, several important systems issues regarding the hospital of presentation affect whether a patient receives rt-PA, such as protocols for acute stroke patient triaging,6 stroke education for local EMS7,8 and ED staff,9,10 and 24-hour CT availability.11 If rt-PA-eligible acute stroke patients arrive at a hospital that is not fully prepared to treat with rt-PA, they may not receive thrombolytic therapy. This has been part of the impetus for the designation of Primary Stroke Centers by JCAHO, a program which has so far certified 546 hospitals across the United States as being capable of receiving hyper-acute stroke patients.12 Yet, despite this recent drive to improve hospital “stroke readiness” and quality of care, many hospitals have not made stroke a priority and have not participated in any stroke-related programs or initiatives.
Therefore, we hypothesized that rt-PA use varies widely by hospital and county region, and that a small number of hospitals may treat the majority of patients with thrombolytic therapy. This is supported by other reports of referral-based rt-PA usage rates of up to 15% for ischemic stroke in the literature,\textsuperscript{13} which contrast sharply with the national average.\textsuperscript{3} We suspected that a large percentage of the US population does not have access to hospitals that regularly use rt-PA. In the present analysis, we describe the geographic distribution of hospitals that use rt-PA for acute ischemic stroke in the United States, and we demonstrate the relationship of these hospitals to local population densities.

\section*{Methods}

This analysis used the MEDPAR database, which is a claims-based dataset that contains every fee-for-service Medicare-eligible hospital discharge in the United States. Medicare-eligible patients consist of nearly all US residents that are $\geq$65 years old, all patients with end-stage renal disease or solid organ transplant, and all patients that have been totally disabled for more than 24 months. Medicare beneficiaries in managed care plans (roughly 15% of Medicare enrollment in 2005) are not captured in the MEDPAR data. Hospitalizations are categorized by Diagnosis Related Group (DRG), which describes the primary reason for admission as determined by billing personnel. The DRG is based on the primary and secondary International Classification of Diseases, version 9 (ICD-9) codes. Reimbursement to hospitals is based primarily on the DRG weights.

Cases potentially eligible for rt-PA treatment based on diagnosis were defined as patient visits with a hospital discharge code of 433, 434, or 436, within DRG 14 (intracranial hemorrhage or stroke with infarct), DRG 15 (nonspecific CVA and precerebral occlusion without infarct), and DRG 524 (transient cerebral ischemia). DRG 524, created in 2003, aims to identify TIA as distinct from DRG 14 and DRG 15. Patient visits with hemorrhagic stroke or TIA ICD-9 codes (430, 431, 432, and 435) were excluded because rt-PA administration is inappropriate for such cases. Cases who received thrombolysis were identified by the presence of ICD-9 procedure code 99.1: injection or infusion of thrombolytic agent (this could denote either intravenous or intra-arterial delivery). The study interval was 7/1/05 to 6/30/07. Hospital locations were mapped using ArcView GIS software; county population densities, in units of persons per square miles, were calculated based on US Census 2000 (obtained from the US Census Bureau website, www.census.gov). We drew a 20-mile radius around each hospital whose treatment rate was at or above the national average of rt-PA treatment within the database during the study period (2.4%, see Results). We chose 20 miles as the length of the radii based on a prior study that demonstrated this as a reasonable distance for emergency medical services coverage (Phillip Scott, MD, personal communication, 2009). Designation of hospitals in rural underserved versus urban areas, as well as population density data, was also obtained from the US Census. Hospitals were stratified by bed size as $<50$, 50 to 200, and $\geq$200 beds, and by location in a county with population density as $<50$, 50 to 500, and $\geq$500 persons per square mile. Region of the United States was defined as Northeast, West, South, and Midwest, according to state definitions on the US Census website. In accordance with HIPAA regulations for the MEDPAR database, no data that represent fewer than 10 claims are presented. An exemption for nonhuman research was obtained from our local Institutional Review Board, as we did not collect any identifying information.

The data were summarized by calculation of mean rt-PA treatment rates and 95% confidence limits for each stratum of bed size, population density, and regions in the United States. We then compared the rt-PA treatment rates among strata for each of these factors using negative binomial regression for each factor individually. Rates were defined as the ratio of the number of rt-PA–treated patients in each hospital to the total number of stroke admissions in each hospital resulting in an analysis weighted by stroke admissions. To assess the effect of each factor while controlling for each of the other factors, we also ran multivariable negative binomial regression models including all three factors.

\section*{Results}

There were 4750 hospitals in the MEDPAR database (Figure 1) within the United States. For reference, the population...
density by county is presented in Figure 2. The hospitals within the MEDPAR database reported 495,186 ischemic stroke admissions during the 2-year study period. Of these ischemic stroke admissions, 11,884 were reported to have received rt-PA, which amounted to 2.4% of all ischemic stroke admissions.

Hospitals that reported treating at or above the national average 2.4% treatment rate are mapped in Figure 3 and supplemental Figure I, available online at http://stroke.ahajournals.org, with a 20-mile radius drawn around each hospital. More detailed maps of each region of the United States are available online only. Individual hospital reported treatment rates ranged from 0% to 23%. There were 3050 hospitals (64.2%) reporting no treatments with rt-PA for ischemic stroke, 893 hospitals (18.8%) reporting rt-PA rates greater than zero up to 2.4%, 762 hospitals (16.0%) reporting rt-PA rates between 2.4 and 10%, and 45 hospitals (0.9%) reporting >10% treatment rates (designated with yellow points on Figure 3). Based on county populations, approximately 162 million U.S. citizens (60% of the US population, based on 2000 Census data) reside in counties that have a hospital that reports a treatment rate >2.4%.

Hospitals that reported no rt-PA use were smaller hospitals with an average bed size of 95, compared with 359 for hospitals that reported treating at 10% or greater. The results of the univariate analysis for hospital-level predictors of rt-PA use are presented in the Table. All 3 variables analyzed, including bed size, rural or underserved designation, and population density were significantly associated with the reported rt-PA treatment rates and remained significant in the multivariable regression, although bed size was the most important factor.

Discussion

We report the first description of US rt-PA treatment rates by hospital. As we hypothesized, we found a wide variation in the reported rates of hospital use of rt-PA for ischemic stroke within the MEDPAR dataset. More than half of US hospitals (62%) did not report giving rt-PA at all within the 2-year study period. These tended to be hospitals that were smaller (average bed size of 95), located in less densely populated areas, or located in the South or Midwest. In addition, 40% of the US population resided in counties without a hospital that reported administering rt-PA to at least 2.4% of its ischemic stroke patients.

We suspect that smaller or more rural hospitals lower rates of treatment is related primarily to volume of eligible patients arriving at these smaller hospitals. The percentage of ischemic stroke patients eligible for rt-PA is only 8% to 9% of all ischemic stroke,5 and for smaller hospitals this could mean only a few eligible cases a year. Just as with many surgical procedures, high-volume experienced centers are able to maintain highly efficient triaging and treatment of acute stroke patients, whereas lower volume centers constantly struggle to maintain vigilance for the potentially treatable patient. We note, however, that after controlling for the number of stroke admissions to individual hospitals in our analysis, bed size and population density were still independent factors, and therefore issues in addition to a hospital’s volume of stroke patients likely affect hospital-specific rates of rt-PA usage. Also, patients that are treated at an outlying hospital, and then transferred to another hospital, are difficult to distinguish within administrative datasets. It is possible that some of the smaller hospitals that have no reported treatments did have some patients treated and transferred.
away; we are unable to detect such patients with the coding paradigm for acute stroke in 2005 to 2007.

These findings have important implications for stroke care in the United States. Such data could assist in identifying underserved, high-population-density areas that may benefit from professional and hospital education by national organizations, such as the American Hospital Association, the CDC, or the American Heart Association. The rural underserved areas, such as many of the western states, could be targeted with either helicopter-based stroke care or telemedicine. JCAHO primary stroke center certification and other national organizations with goals of improving rt-PA treatment rates and the quality of care for stroke patients will find these results useful for informing their initiatives.

This analysis has several limitations. First, we have previously demonstrated that the ICD-9 code 99.1 is not particularly sensitive for detecting rt-PA treatment. However, our prior analysis, which used pharmacy records compared to ICD-9 codes, dealt with data collected before the creation of DRG 559, which provides improved reimbursement for patients treated with rt-PA and requires the ICD-9 procedure code 99.1. We believe that this new incentive for proper coding of rt-PA treatment will improve the sensitivity of the 99.1 code, but this still needs to be shown.

A second limitation is the MEDPAR database itself, in that it does not include patients younger than 65 years of age, except for transplant and permanently disabled patients. Our previous study, mentioned above, found that this arbitrary age cut-off misses a substantial number of rt-PA treated patients. Because of this limitation, we have not presented actual percentages or raw numbers of treatments by hospital; instead, all data are presented relative to a pooled national average which carries the same limitation. We felt that this would still be useful for assessing public access to regularly-treating hospitals and identifying relatively underserved areas. Also, approximately 15% of Medicare beneficiaries are enrolled in managed care plans, and are not contained within the MEDPAR database; this could potentially bias our findings as well. It should also be noted that county-based population densities are probably not representative of the catchment areas of hospitals, which often cross county lines. The 20-mile radius to describe access to care is arbitrary; it is likely too big for a dense urban area, and too small for a rural region. However, it was thought to be a reasonable national compromise.

A final limitation is the fact that some patients are transferred to other hospitals after rt-PA administration, as mentioned above. In the study period, the ICD-9 code 99.1 could be used only for patients treated and admitted to the same hospital. Cases treated at one hospital and immediately transferred to another (“drip and ship” patients) did not
Table. Univariate and Multivariable Regression of Hospital-Level Predictors of Rt-PA Treatment, MEDPAR Database, n=4626 Hospitals

<table>
<thead>
<tr>
<th>Bed size (number of beds/hospital)</th>
<th>Univariate (95% CI)*</th>
<th>Multivariable Regression (P Value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;50</td>
<td>0.3% (0.2% to 0.4%)</td>
<td>0.001</td>
</tr>
<tr>
<td>50–200</td>
<td>1.1% (1.0% to 1.2%)</td>
<td></td>
</tr>
<tr>
<td>&gt;200</td>
<td>2.6% (2.4% to 2.8%)</td>
<td></td>
</tr>
<tr>
<td>Region of United States</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midwest</td>
<td>2.0% (1.7% to 2.2%)</td>
<td>0.001</td>
</tr>
<tr>
<td>Northeast</td>
<td>2.7% (2.3% to 3.1%)</td>
<td></td>
</tr>
<tr>
<td>South</td>
<td>1.8% (1.6% to 2.1%)</td>
<td></td>
</tr>
<tr>
<td>West</td>
<td>2.5% (2.1% to 2.9%)</td>
<td></td>
</tr>
<tr>
<td>Population density (persons/sq. mile)</td>
<td>21.3 (0.001)</td>
<td></td>
</tr>
<tr>
<td>&lt;50</td>
<td>0.9% (0.7% to 1.1%)</td>
<td></td>
</tr>
<tr>
<td>50–500</td>
<td>1.7% (1.6% to 1.9%)</td>
<td></td>
</tr>
<tr>
<td>&gt;500</td>
<td>2.7% (2.5% to 3.0%)</td>
<td></td>
</tr>
</tbody>
</table>

*Means are weighted by the total No. of stroke admissions to the hospital during the study period.

In summary, we report a nationwide description of reported rates of rt-PA use by hospital. There were many hospitals that did not report any rt-PA treatments in the MEDPAR dataset during the 2-year study period. We found that smaller rural hospitals, and hospitals in the South and Midwest, were less likely to report giving rt-PA to stroke patients, although patients transferred away are difficult to track within administrative datasets. These data provide a national perspective regarding rt-PA use, and may help in planning resource utilization and strategies to increase the use of rt-PA overall.

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Disclosures
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References
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