Potential Applicability of Recombinant Factor VIIa for Intracerebral Hemorrhage

Matthew L. Flaherty, MD; Daniel Woo, MD, MS; Mary Haverbusch, BSN; Charles J. Moomaw, PhD; Padmini Sekar, MS; Laura Sauerbeck, RN, MS; Brett Kissela, MD; Dawn Kleindorfer, MD; Joseph P. Broderick, MD

Background and Purpose—To date, there are no proven, effective treatments for intracerebral hemorrhage (ICH) beyond supportive medical care. A recent randomized, blinded, placebo-controlled trial of recombinant factor VIIa (rFVIIa) administered intravenously within 4 hours of ICH onset reported a reduction in morbidity and mortality compared with placebo. We sought to determine the potential applicability of rFVIIa in a large, population-based cohort of ICH patients.

Methods—All of the patients age ≥18 years hospitalized with nontraumatic ICH in the Greater Cincinnati region were identified from May 1998 to July 2001 and August 2002 to April 2003. Patient demographics were compared with the inclusion and exclusion criteria from the rFVIIa trial to determine eligibility for treatment and reasons for exclusion. Mortality in the eligible patient group was compared with the placebo group in the rFVIIa trial.

Results—Over 4 calendar years, 1018 ICH patients were identified; of these, 133 (13.1%) had no exclusions and presented within the prescribed time window. An additional 45 patients (4.4%) may have been eligible but had uncertain onset or computed tomography scan times. The most common reasons for exclusion (not mutually exclusive) were late presentation (n=398), vaso-occlusive disease (n=369), deep coma (n=219), and prolonged international normalized ratio or partial thromboplastin time (n=200). Mortality at 90 days among potentially eligible patients was the same as for the placebo group in the rFVIIa trial (29% versus 29%; P=0.99).

Conclusions—In this large, population-based ICH cohort, 13.1% to 17.5% of patients would have qualified for treatment with rFVIIa by trial criteria. (Stroke. 2005;36:2660-2664.)

Key Words: intracerebral hemorrhage ■ epidemiology ■ outcome

Intracerebral hemorrhage (ICH) is conservatively estimated to occur in 67,000 Americans annually and disproportionately affects blacks and Hispanics.1–3 It is frequently a devastating illness, with case fatality rates of 40% to 50%.4,5 There have been no proven, effective treatments for ICH. However, a recent randomized, placebo-controlled, phase IIb trial of recombinant activated factor VII (rFVIIa) in acute ICH showed a reduction in morbidity and mortality among patients given study drug.6 If the safety and efficacy of rFVIIa are confirmed in a phase III trial, it will represent a major advance in the treatment of hemorrhagic stroke.

The successful translation of new treatments, such as rFVIIa, from controlled trials to clinical practice is of vital importance. As an analogous example, recombinant tissue plasminogen activator (rtPA), shown to reduce morbidity in appropriately selected patients with acute ischemic stroke in 1995, is the only US Food and Drug Administration (FDA)-approved treatment for this condition.7 Despite initial enthusiasm, subsequent experience has shown that very few ischemic stroke patients actually receive thrombolysis. Estimates indicate that 6% to 8% of ischemic stroke patients are potentially eligible for rtPA based on published criteria and that 3% to 4% receive the medication.5–10 Just as use of rtPA for ischemic stroke requires diligent patient selection, the trial of rFVIIa for ICH specified strict inclusion and exclusion criteria intended to maximize the potential benefit and minimize adverse effects.6,7 Patients were required to have a computed tomography (CT) scan within 3 hours of symptom onset, and patients with a history of vaso-occlusive disease were excluded, given the potential of rFVIIa to accentuate thrombosis and induce ischemic stroke or myocardial infarction.6 We sought to determine the potential applicability of rFVIIa in practice by applying trial inclusion and exclusion criteria to a large, population-based cohort of ICH patients.

Methods

We have previously described a population-based ICH cohort assembled as part of the Genetic and Environmental Risk Factors for Stroke is available at http://www.strokeaha.org DOI: 10.1161/01.STR.0000189634.08400.82

Received June 17, 2005; final revision received July 20, 2005; accepted August 9, 2005.

From the Departments of Neurology (M.L.F., D.W., M.H., C.J.M., L.S., B.K., D.K., J.P.B.) and Environment Health (P.S.), University of Cincinnati Medical Center, Cincinnati, OH.

Correspondence to Matthew L. Flaherty, MD, 231 Albert Sabin Way, MSB Room 5060, University of Cincinnati Medical Center, Cincinnati, OH, 45267-0525. E-mail matthew.flaherty@uc.edu

© 2005 American Heart Association, Inc.
Hemorrhagic Stroke (GERFHS) Study. All of the patients ≥18 years of age who were hospitalized with nontraumatic ICH in the 5-county Greater Cincinnati/Northern Kentucky (GCNK) metropolitan area were identified from May 1998 to July 2001 and August 2002 to April 2003 by active surveillance ("hot pursuit") at several hospitals that treat most ICH in the area and by retrospective screening of primary and secondary ICD-9 codes (430 to 432 through October 1999 and 430 to 438.9 thereafter) at all of the regional hospitals. The period August 2001 to July 2002 was not included because of an interruption of study funding during that time. Study physicians personally reviewed each abstracted file to determine whether it qualified as a case.

The GCNK region has a population of 1.3 million persons with socioeconomic demographics and a balance of blacks and whites similar to the US population. Residents of the 5-county GCNK region seek care almost exclusively at 1 of the 16 participating metropolitan hospitals, ensuring nonbiased case ascertainment. The definition of ICH used has been described elsewhere. The present cohort included patients with previous ICH (but not previous ischemic stroke), traumatic ICH, pure intraventricular hemorrhage, hemorrhagic cerebral infarction, and hemorrhage associated with brain tumor,encephalitis, endarterectomy, and thrombotic treatment of ischemic stroke. ICHs associated with vascular malformations or anticoagulation were included. The GERFHS Study was approved by the Institutional Review Boards at all of the participating hospitals.

The inclusion criteria of the rFVIIa trial were age ≥18 years, spontaneous ICH documented by CT scan within 3 hours of onset, and drug administration within 1 hour of CT scan. Exclusion criteria are listed in Table 1. These criteria were applied to the clinical characteristics of patients in our ICH cohort to determine eligibility for treatment with rFVIIa. For criteria other than time from onset to CT scan, elements of missing data were not considered exclusionary.

### TABLE 1. Application of rFVIIa Trial Criteria to the GCNK ICH Cohort

<table>
<thead>
<tr>
<th>Exclusion Criteria*</th>
<th>Definitely (%)</th>
<th>Possibly† (%)</th>
<th>No (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients</td>
<td>340 (33)</td>
<td>280 (28)</td>
<td>398 (39)</td>
<td>1018 (100)</td>
</tr>
<tr>
<td>History of thrombotic or vaso-occlusive disease‡</td>
<td>112 (11)</td>
<td>118 (12)</td>
<td>139 (14)</td>
<td>369 (36)</td>
</tr>
<tr>
<td>Deep coma (GCS 3–5)</td>
<td>83 (8)</td>
<td>99 (10)</td>
<td>37 (4)</td>
<td>219 (22)</td>
</tr>
<tr>
<td>INR ≥1.4 or PTT &gt;35</td>
<td>53 (5)</td>
<td>77 (8)</td>
<td>70 (7)</td>
<td>200 (20)</td>
</tr>
<tr>
<td>Baseline mRS score &gt;2</td>
<td>27 (3)</td>
<td>61 (6)</td>
<td>56 (6)</td>
<td>144 (14)</td>
</tr>
<tr>
<td>Surgical drainage within 24 hours</td>
<td>26 (3)</td>
<td>21 (2)</td>
<td>18 (2)</td>
<td>65 (7)</td>
</tr>
<tr>
<td>ICH from aneurysm or vascular malformation</td>
<td>10 (1)</td>
<td>3 (0)</td>
<td>10 (1)</td>
<td>23 (2)</td>
</tr>
<tr>
<td>Platelet count ≤50 000</td>
<td>2 (0)</td>
<td>7 (1)</td>
<td>1 (0)</td>
<td>10 (1)</td>
</tr>
<tr>
<td>Coagulopathy, DIC, or hypercoagulable state</td>
<td>1 (0)</td>
<td>1 (0)</td>
<td>1 (0)</td>
<td>3 (0)</td>
</tr>
<tr>
<td>Pregnancy</td>
<td>2 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>2 (0)</td>
</tr>
<tr>
<td>Crush injury</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Acute sepsis</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>No exclusions</td>
<td>133 (13)</td>
<td>45 (4)</td>
<td>183 (18)</td>
<td>361 (35)</td>
</tr>
</tbody>
</table>

| GCS indicates Glasgow Coma Scale; mRS, modified Rankin Scale; DIC, disseminated intravascular coagulation. | Because some patients have ≥1 reason for exclusion, the sum of the individual categories exceeds the number in the "all patients" category; †includes patients with uncertain ICH onset times or CT scan times that potentially overlapped the acceptable time frame; ‡including history of angina, claudication, deep vein thrombosis, cerebral infarction, or myocardial infarction. |

---

**Results**

Over 4 calendar years, 1018 ICH patients were identified. Of these patients, 133 (13.1%) had no exclusions and presented within the prescribed time window. An additional 45 patients (4.4%) may have qualified but had uncertain onset or CT scan times that potentially overlapped the acceptable time frame. In total, 133 to 178 patients (13.1% to 17.5%) with ICH would have been eligible for rFVIIa. The reasons for exclusion are presented in Table 1. The most common (not mutually exclusive) reasons for exclusion were late presentation (n=398; 39%), history of vaso-occlusive disease (n=369; 36%), deep coma (n=219; 22%), and prolonged INR or PTT (n=200; 20%). If time were not a factor, an additional 183 patients (18%) would have qualified for treatment. If a history of vaso-occlusive disease was not an exclusion, an additional 58 to 91 patients would have qualified, increasing the overall eligibility to 19% to 26%. Of the 130 patients with a prolonged INR or PTT who were possibly scanned within 3 hours, only 26 patients had no other contraindications to rFVIIa.

The 5-county Greater Cincinnati/Northern Kentucky region currently has 16 general hospitals and 1 children’s hospital. Cases of ICH in the area are usually transferred to 1 of 3 tertiary centers, unless care is anticipated to be nonoperative or limited to end-of-life measures. Only 287 of 1018 ICH patients (28%) originally presented to 1 of these tertiary centers, including 59 patients potentially eligible for rFVIIa (33% of eligible patients).

A comparison of baseline characteristics among placebo patients from the rFVIIa trial and patients from our ICH cohort is presented in Table 2. Survival curves for patients from the rFVIIa trial and patients from our population who would have been potentially eligible and ineligible for rFVIIa are presented in the Figure. Among our population, mortality at 90 days was 29% for potentially eligible patients versus 52% for ineligible patients (P<0.001). In the rFVIIa trial, 90-day mortality among placebo patients was 29%, the same as our potentially eligible group (P=0.99 by χ² test; P=0.80 by log rank test). The absolute mortality benefit for rFVIIa
patients compared with placebo patients in the trial was 11% 
\( (P=0.02) \).\textsuperscript{6} If this benefit is applied to the eligible group in our ICH cohort, 90-day mortality for our entire cohort (both eligible and ineligible patients) would have dropped from 48% to 46%. Death or severe disability at 3 months (as defined by modified Rankin Scale scores of 4 to 6 and extended Glasgow Outcome Scale scores of 1 to 4) occurred in 69% of placebo patients and 53% of rFVIIa-treated patients \( (P=0.004) \).\textsuperscript{6} If 17.5% of the estimated 67 000 annual ICHs in the United States were treated with rFVIIa, and their natural history paralleled the rFVIIa trial group, this would translate into 1290 lives saved and 1876 patients prevented from experiencing death or severe disability.\textsuperscript{1,6} In the rFVIIa trial, 2% of placebo patients and 7% of rFVIIa patients experienced thromboembolic serious adverse events \( (P=0.12) \).\textsuperscript{6} Extrapolated nationally, this would result in an excess of 586 serious adverse events among treated patients.

\textbf{Discussion}

The majority of ICH mortality occurs early in the clinical course.\textsuperscript{5} More than one third of ICH patients experience substantial hematoma growth within a day of ictus, and this

---

**TABLE 2. Comparison of rFVIIa Study Patients and the GCNK ICH Cohort**

<table>
<thead>
<tr>
<th>Variable</th>
<th>rFVIIa Study, Placebo Group\textsuperscript{6}</th>
<th>GCNK Cohort, Eligible Patients</th>
<th>GCNK Cohort, Eligible and Possibly Eligible Patients\textsuperscript{*}</th>
<th>GCNK Cohort, Not Eligible</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>96</td>
<td>133</td>
<td>178</td>
<td>840</td>
</tr>
<tr>
<td>Age, mean (SD)</td>
<td>68 (12)</td>
<td>66 (16)</td>
<td>67 (16)</td>
<td>71 (15)</td>
</tr>
<tr>
<td>Male, %</td>
<td>53</td>
<td>47</td>
<td>46</td>
<td>44</td>
</tr>
<tr>
<td>Race or ethnic group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White, %</td>
<td>81</td>
<td>72</td>
<td>74</td>
<td>79</td>
</tr>
<tr>
<td>Black, %</td>
<td>NR</td>
<td>28</td>
<td>26</td>
<td>19</td>
</tr>
<tr>
<td>Asian or Pacific Islander, %</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Other, %</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Location of ICH, %\textsuperscript{†}</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deep cerebral ICH</td>
<td>68</td>
<td>65</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Lobar ICH</td>
<td>21</td>
<td>23</td>
<td>27</td>
<td>37</td>
</tr>
<tr>
<td>Cerebellar ICH</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Brainstem ICH</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>GCS, median</td>
<td>14</td>
<td>15</td>
<td>15</td>
<td>13</td>
</tr>
</tbody>
</table>

NR indicates not reported. \*Includes patients with uncertain ICH onset times or CT scan times that potentially overlapped the acceptable time frame; \†1 region could be involved in a given patient in the rFVIIa study; therefore, percentages by location do not total 100%. Percentages by location in the GCNK cohort do not total 100% because of rounding; \‡Putamen or globus pallidus is 58% and thalamus is 30%.
growth is associated with increased morbidity and mortality.14–16 Thus, prompt intervention to prevent hematoma expansion, as with intravenous administration of rFVIIa, may improve patient outcomes. A phase III trial of rFVIIa in ICH is currently underway. If rFVIIa proves safe and effective and is given FDA approval for use in ICH, its applicability will be of importance.

It is useful to compare the potential applicability of rFVIIa for treatment of ICH with the use of rt-PA for ischemic stroke in community patients. Despite enthusiasm among many physicians following FDA approval of rtPA in 1996, thrombolytic treatment of ischemic stroke remains rare, with 6% to 8% of patients potentially qualifying for rt-PA and 3% to 4% of patients receiving treatment in community-based surveillance.9,10,17 Approximately 15% to 27% of ischemic stroke patients arrive in the emergency department within 3 hours of onset.9,10,17 The number eligible for rt-PA is additionally reduced by factors including strokes judged too mild for thrombolytic treatment, comorbid medical conditions, and inefficient medical systems.

Approximately 13% to 18% of our ICH cohort would have qualified for rFVIIa treatment, 2 to 3 times the rtPA eligibility rate of ischemic stroke patients. It should be noted, however, that the absolute number of ICH patients treated would likely be less than ischemic stroke patients receiving rtPA, because the incidence of ICH is considerably lower than that of ischemic stroke.1

Our study confirms that patients with ICH present to the emergency department more quickly than patients with ischemic stroke, presumably because greater severity of deficits prompts a more rapid recognition of the need for medical care.18,19 CT scanning was performed in 340 of 1018 patients within 3 hours of symptom onset, and another 280 may have received a scan within this time (33% to 60% of patients). Attempts to educate the public about the importance of early medical evaluation for the signs and symptoms of stroke have been marginally successful thus far.20

Aside from late presentation, other common reasons that hemorrhage patients would be excluded from potential treatment are deep coma, a history of vaso-occlusive disease, and anticoagulant use. Patients in deep coma from ICH have very poor prognoses and are unlikely to benefit from rFVIIa.21 Patients with vaso-occlusive disease may benefit from rFVIIa but may also be at increased risk of adverse events, such as myocardial infarction, cerebral infarction, and pulmonary embolism. The ongoing phase III trial of rFVIIa includes patients with a history of vaso-occlusive disease (but not acute thromboembolic events). By our estimates, this may increase rFVIIa applicability to 19% to 26% of ICH patients, but its affect on adverse event rates is unknown and of great importance.

The most logical potential extension of rFVIIa treatment is for cases of warfarin-associated ICH, because these patients have greater hematoma expansion and worse outcomes than other ICH patients.22 rFVIIa use has been reported in several small series of warfarin-related bleeding with encouraging results.23–25 Although rFVIIa rapidly reverses INR prolongation, it does not replace all of the deficient coagulation factors, and “correction” of INR values in this setting may not reflect the therapeutic mechanism of rFVIIa or the status of the underlying coagulopathy.26,27 In our population, 200 patients (20%) with ICH had a prolonged INR or PTT, including 130 patients possibly receiving a CT scan within 3 hours of onset. However, 104 of these 130 patients had other reasons for exclusion (most commonly a history vaso-occlusive disease or deep coma). Thus, if prolonged PTT or INR values were not exclusions, only an additional 26 patients (3%) would have qualified.

Although the rFVIIa study showed an impressive reduction in mortality among treated ICH patients, application of these findings to our entire population of ICH patients produced a modest 2% reduction in overall 90-day mortality. Nonetheless, this mortality reduction could save >1200 lives annually in the United States and prevent death or severe disability in >1800 patients. The impact may be even greater in Asian countries, which have higher rates of ICH than the United States or Europe.28–30 The fact that mortality rates in the rFVIIa placebo group and our potentially eligible patient group were identical suggests that the rFVIIa trial included a representative sample of ICH patients who met inclusion criteria and increases the likelihood that study findings will translate into benefit in clinical practice.

Finally, most of our ICH patients presented to hospitals that do not offer tertiary care for this condition. In communities like ours, without preferential triage of stroke patients to select medical centers by emergency services, community hospitals will need to be capable of administering rFVIIa to appropriate patients.

Our study has several limitations. Our cohort did not include patients with ICH related to trauma, tumor, infection, or cerebral infarction, and so we cannot comment on their prevalence. Each of these conditions was an exclusion criterion in the rFVIIa study. Our cohort also excluded patients with previous ICH, who may benefit from rFVIIa treatment. Because data collection was often retrospective, values were sometimes missing or not aggressively pursued by attending physicians when deemed irrelevant to patient care. If rFVIIa is proven effective, emergency care of ICH patients may change and with it drug applicability.

Acknowledgments
Supported in part by National Institute of Neurological Disorders and Stroke (R-01-NS 36695). Special thanks to Dr Nikolai C. Brun, Dr Kamilla Begtrup, and Novo Nordisk for providing mortality data from the rFVIIa Intracerebral Hemorrhage Trial.

References


Potential Applicability of Recombinant Factor VIIa for Intracerebral Hemorrhage
Matthew L. Flaherty, Daniel Woo, Mary Haverbusch, Charles J. Moomaw, Padmini Sekar, Laura Sauerbeck, Brett Kissela, Dawn Kleindorfer and Joseph P. Broderick

Stroke. 2005;36:2660-2664; originally published online November 3, 2005;
doi: 10.1161/01.STR.0000189634.08400.82
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2005 American Heart Association, Inc. All rights reserved.
Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://stroke.ahajournals.org/content/36/12/2660

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Stroke can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Stroke is online at:
http://stroke.ahajournals.org//subscriptions/