T he recanalization of thromboembolic occlusions in the posterior circulation is a challenge that interventional neuroradiology must still meet. Local intra-arterial fibrinolysis has improved the outcome of patients with vertebrobasilar occlusion, increasing the survival rate from 10% to 15% on heparin therapy alone1–3 to approximately 30% to 45% (with highest and lowest values excluded).2,4–8 The recanalization rates range from 50% to 75% (with highest and lowest values excluded).2,4–8 All studies report that the outcome is dependent on recanalization, which improves the survival rates by 45% to 55% (with highest and lowest values excluded).2,4–8 Therefore, we sought a mechanical means of recanalization and tested different devices. Until now no device has been flexible enough to guarantee intracranial access or has been appropriate for handling different kinds of emboli without fragmenting them. After training in an ex vivo flow model and a pig model of acute arterial thromboembolism, we participated in a phase I multicenter study (Neuronet Evaluation in Embolic Stroke Disease [NEED]) on the treatment of acute basilar and middle cerebral artery occlusion.

Subjects and Methods
The use of the Guidant Neuronet was approved by our local ethics committee. This microguidewire-based device consists of a nitinol basket that can be pushed through a standard microcatheter. The self-expanding basket has more struts distally than proximally and is attached to the microwire eccentrically to load the thrombus. The device had to be advanced distally to the thrombus. After the microcatheter, which acts as a sheath, was removed, the embolus was retracted with the expanded basket (Figure 1). All procedures were performed during heparin administration (partial thromboplastin time >60 seconds or activated clotting time >250 seconds).
Table 1. Angiographic Findings, Techniques, and Recanalization Results

<table>
<thead>
<tr>
<th>Patient</th>
<th>Occlusion Length, mm</th>
<th>PCom</th>
<th>PICA</th>
<th>Flow Control</th>
<th>TIMI Grade in BA</th>
<th>P2 Clot Migration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Before Therapy</td>
<td>After Neurorint</td>
<td>After Fibrinolysis</td>
</tr>
<tr>
<td>1</td>
<td>15</td>
<td>0</td>
<td>++</td>
<td></td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>0</td>
<td>++</td>
<td></td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>+</td>
<td>+</td>
<td>Silicone balloons in both VA</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>++</td>
<td>+</td>
<td>Silicone balloon in left subclavian artery</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
<td>++</td>
<td>0</td>
<td>Coaxial catheters in both VA</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

PCom indicates posterior communicating artery; PICA, posterior inferior cerebellar artery; TIMI, Thrombolysis in Myocardial Infarction; BA, basilar artery; P2, second segment of posterior cerebral artery; collateral status: 0, none; +, moderate; ++, good; TIMI 0, occlusion; TIMI 1, subtotal obstruction; TIMI 2, stenosis; TIMI 3, open vessel; and VA, vertebral artery.
cytes to erythrocytes to leukocytes in the thrombus was found to be 25%/60%/15% (patient 3), 35%/30%/35% (patient 4), and 50%/40%/10% (patient 5), respectively.

All 5 patients were still alive at the 3-month follow-up. Patient 3 was neurologically asymptomatic soon after intervention (from Glasgow Coma Scale score of 4 and National Institutes of Health Stroke Scale score of 24 at admission), patient 4 also recovered to a great extent on the first day, and patient 1 became well within a few days (Table 2).

**Discussion**

The outcome of acute vertebrobasilar occlusion depends on both a successful recanalization2,4,6–8 and the time since onset of progressive stroke and coma.10 We have found that the recanalization rate depends on the thrombus mass (T.E. Mayer, MD, et al, unpublished data, 1998). There is evidence that the recanalization rate also depends on the length of the occluded segment.7 The time required for recanalization includes the time for microcatheter placement and the duration of fibrinolysis, together a total of approximately 2 to 3 hours. According to our unpublished experience with 150 patients with occlusions of the vertebrobasilar system, fibrinolysis causes migration of the clot into the posterior cerebral arteries in the vast majority.

There are reports that the use of the platelet glycoprotein IIb/IIIa inhibitors abciximab and tirofiban, in combination with fibrinolysis, seems to improve recanalization without increasing bleedings.11–13 Several studies are now in progress, but prospective multicenter studies are necessary to determine whether systemic or intra-arterial therapy provides the best benefit for patients. It is likely that both methods or a combination of the 2 will be the answer. The problem is demonstrated by a case in which the combination of heparinization, urokinase, and abciximab did not succeed in recanalizing the middle cerebral artery, but a mechanical device (goose neck snare) was effective.14

Initially we had hoped that the device would help to reduce large thrombus masses, shorten recanalization time, avoid distal embolization, and provide an alternative treatment for patients in whom fibrinolysis is contraindicated. Despite the good results achieved with human thrombus in the flow model and in animal experiments, the device failed if the basilar artery flow was not reversed. Even low antegrade flow in the artery limited the success of the device. Additional means, such as suction with a coaxial catheter or connection with the venous system, are necessary. Flow control by silicone balloons requires extra time for additional arterial

<table>
<thead>
<tr>
<th>Patient</th>
<th>Sex</th>
<th>Age, y</th>
<th>Time to Inclusion, h</th>
<th>MRS</th>
<th>GCS</th>
<th>NIHSS</th>
<th>Barthel Index</th>
<th>MRS</th>
<th>GCS</th>
<th>NIHSS</th>
<th>Barthel Index</th>
<th>MRS</th>
<th>GCS</th>
<th>NIHSS</th>
<th>Barthel Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>55</td>
<td>4.75</td>
<td>3</td>
<td>11</td>
<td>8</td>
<td>25</td>
<td>2</td>
<td>15</td>
<td>2</td>
<td>90</td>
<td>1</td>
<td>15</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>72</td>
<td>9</td>
<td>5</td>
<td>4</td>
<td>25</td>
<td>0</td>
<td>4</td>
<td>9</td>
<td>23</td>
<td>10</td>
<td>4</td>
<td>10</td>
<td>23</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>17</td>
<td>10</td>
<td>4</td>
<td>4</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>15</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>21</td>
<td>4.5</td>
<td>3</td>
<td>13</td>
<td>18</td>
<td>35</td>
<td>1</td>
<td>15</td>
<td>1</td>
<td>100</td>
<td>1</td>
<td>15</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>46</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>26</td>
<td>0</td>
<td>5</td>
<td>8</td>
<td>21</td>
<td>0</td>
<td>5</td>
<td>8</td>
<td>20</td>
<td>0</td>
</tr>
</tbody>
</table>

MRS indicates Modified Rankin Scale; GCS, Glasgow Coma Scale; and NIHSS, National Institutes of Health Stroke Scale.
accesses; however, our last case demonstrated that recanalization time can still be shortened if fibrinolysis can be avoided. The use of coaxial catheter suction alone often proves unsuccessful if the catheter is not near the clot. It is remarkable that when flow control is used, distal embolization does not occur. Since blockade of the vertebral or the subclavian arteries was necessary for only a few minutes, this should not harm the patients. While the neurological deficits of 2 patients immediately improved after use of this technique, 1 patient remained unchanged as a result of pontine infarction at the level of the embolus. Nevertheless, it is necessary to determine the possible complications in further studies.

While the use of the current device is helpful for recanalization procedures in acute thromboembolic stroke, it must still be improved. On the basis of our preliminary experience with various mechanical devices for extracting thrombus material from the intracranial arteries, we recommend the use of flow control to support the retrieval of the thrombus (which the proximal flow would otherwise keep in place like a cork) and to protect the distal vessels from embolization due to settling fragments. While carotid stent systems for proximal flow control are becoming increasingly available, they are too large. Devices appropriate for proximal flow control also must be developed for the posterior circulation.

Conclusion
Mechanical thrombus extraction is a feasible method for preventing infarction by rapid, complete, and safe recanalization of the basilar artery. The Guidant Neuronet device requires flow reversal to ensure a successful recanalization.

Acknowledgments
We thank J. Benson, Department of Neurology, for copyediting the manuscript and S. Wartini, Media Department, for arranging the image tables.

References
Treatment of Basilar Artery Embolism With a Mechanical Extraction Device: Necessity of Flow Reversal

Thomas E. Mayer, Gerhard F. Hamann and Hartmut J. Brueckmann

Stroke. 2002;33:2232-2235
doi: 10.1161/01.STR.0000024524.71680.C6
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2002 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/33/9/2232

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/