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

Thomas E. Mayer, MD; Gerhard F. Hamann, MD; Hartmut J. Brueckmann, MD

Background and Purpose—The success of local fibrinolysis in vertebrobasilar thromboembolism depends on the volume and composition of the clot. Since thrombolysis can also be time consuming and cause bleeding, we investigated the feasibility of a mechanical clot retraction device based on a nitinol basket advanced through a microcatheter.

Methods—Five patients with acute embolism of the basilar artery who presented with progressive stroke and impaired consciousness were included in a multicenter study (Neuronet Evaluation in Embolic Stroke Disease [NEED]). In 3 patients flow reversal was induced with the use of silicone balloons or coaxial catheters. Three patients required additional fibrinolysis.

Results—The device failed to retrieve the clots in our first 2 patients with distal basilar artery embolism. After successful recanalization by local fibrinolysis, both patients survived, 1 disabled and 1 with little residual impairment. In the next 3 patients the anterograde flow in the basilar artery was reversed during the short retraction period by temporarily blocking the vertebral or subclavian arteries. Two of these patients were completely recanalized by solely mechanical means; the third patient needed additional fibrinolysis before also being recanalized. All 3 patients survived: 1 remained disabled, 1 had almost a full recovery, and 1 became asymptomatic the day after the procedure.

Conclusions—Mechanical thrombus extraction seems to be a feasible method for preventing infarction by rapid, complete, and safe recanalization of the basilar artery. We recommend the use of flow control to support retrieval of the thrombus (which the proximal flow would otherwise keep in place like a cork) and to protect the distal vessels from embolization by fragments. (Stroke. 2002;33:2232-2235.)

Key Words: basilar artery ■ stroke, acute ■ thrombi

The 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).2,4–9 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).2,4–6,8 Thrombolysis can, however, also cause hemodynamically relevant bleedings, and intracerebral hematomas in the posterior circulation are reported to occur at a rate of 0% to 15%.2,4–9 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 excentrically 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).

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None of the authors has a financial interest or shares in the product or manufacturing company (Guidant Cooperation, Menlo Park, Calif. None of the authors has received personal payments. The device was provided free to the investigators and the home academic institution will receive payments per patient for carrying out the study.
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2232
The device was used without flow control in the first 2 patients. Flow reversal was induced in the basilar artery in the last 3 patients during retraction by transiently blocking both vertebral arteries with nontetherable silicone balloons (patient 3), the left subclavian artery with a nontetherable silicone balloon (patient 4), and both vertebral arteries with coaxial catheters (patient 5). Patients 1, 2, and 4 were also administered recombinant tissue plasminogen activator (rtPA) intra-arterially.

Because none of the patients were conscious enough to consent to participate, an independent neurologist approved of their inclusion in the study in accordance with the requirements of our local ethics committee.

Results

Five patients (1 female; aged 17 to 72 years; mean age, 42 years) were treated. The angiographic findings showed that all patients had an acute basilar embolism in a typical location (tip of the basilar artery in patients 1 through 4 and midbasilar in patient 5) and no stenosis. The cause of the embolization varied: heart wall aneurysm and discontinuation of warfarin therapy because of a tooth extraction (patient 1), cardiomyopathy and continuous arrhythmia (patient 2), open foramen ovale and deep phlebothrombosis of the leg (patient 3), protein S deficiency (patient 4), and complication in coronary angiography (patient 5). The 5 patients had had a progressive brain stem stroke that had lasted 4 to 10 hours (mean, 6.45 hours). All had reduced consciousness; hemiparesis, paraparesis, or tetraparesis; dysarthria or dysphagia; and, except for patient 5, oculomotor disturbances.

The angiographic results are given in Table 1. Four initial attempts in the first 2 patients with distal basilar artery thromboembolism failed to retract the embolus. In the first patient, the device either did not load properly or did not hold the clots. In the second patient, only a small part of the throbuss was eliminated but not recovered. Both patients were then successfully recanalized by local fibrinolysis (120 and 85 mg rtPA for 3 and 2 hours, respectively). Occlusions due to thrombus migration remained in the P2 segments of the posterior cerebral artery (in patient 1 on the right, in patient 2 on the left).

Proximal vertebral or subclavian blockade was temporarily applied in the next 3 patients to control basilar artery flow. The thrombus was retracted from the basilar artery in patients 3 and 5 by the device. Suction was also applied during retraction in patient 5, and 40 minutes after the start of angiography the vertebrobasilar system was completely recanalized without distal embolization (Figure 2). In the third patient a part of the thrombus was lost in the left vertebral artery at the confluens. The balloon in the right vertebral artery was then deflated, and flow to the basilar artery was reestablished. Blockade of the left vertebral artery was maintained until the thrombus could be suctioned into the coaxial catheter. Complete recanalization was achieved (Figure 3). Three retraction maneuvers were necessary in the fourth patient: at first the left P1 segment of the PCA was recanalized, then the right P1, and finally the basilar tip. After a remaining portion in the basilar tip was treated by local fibrinolysis (60 mg rtPA), complete recanalization was achieved (Figure 4, Table 1).

The retrieved material in the last 3 patients was identified histologically to be fresh thrombus. The relation of thrombo-

**Figure 1.** The following parts of the device are visible, from left to right: microcatheter (0.75 mm), which serves as a sheath and in which the basket is advanced; microwire, which is connected to the basket; and self-expandable nitinol basket, which is released by retraction of the microcatheter. It loads the thrombus by retraction through the vessel; note the soft platinum coil tip.

**Figure 2.** Patient 5. Left, Angiography of the right vertebral artery shows proximal basilar artery embolism. Middle, Digital subtraction angiography image of the retraction of the device from the left posterior cerebral artery through the left vertebral artery (primary location white, recent location black). The right vertebral artery is blocked by a 6F catheter, the left vertebral artery by an 8F catheter (at the lower border of the image). Right, Final result shows complete recanalization after 1 attempt with the use of the device combined with suction by the left coaxial catheter.

### 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 Before Therapy</th>
<th>After Neurionet</th>
<th>After Fibrinolysis</th>
<th>P2 Clot Migration</th>
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<tr>
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<td>0</td>
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<td>3</td>
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</tr>
<tr>
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<td>0</td>
<td>++</td>
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<td>Yes</td>
</tr>
<tr>
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<td>+</td>
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</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>
<td>3</td>
<td>No</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>
<td>…</td>
<td>No</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 inter-
vention (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.
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 dura-
tion 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, fibri-
nolysis 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 deter-
mine 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 hepa-
rinization, 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

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**TABLE 2. Clinical Status on Admission and Outcome After 30 and 90 Days**

<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>
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<tr>
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<td>4.75</td>
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<td>72</td>
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<td>4</td>
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<tr>
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<td>17</td>
<td>10</td>
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<td>0</td>
</tr>
<tr>
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<td>3</td>
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<tr>
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<td>M</td>
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<td>5</td>
<td>3</td>
<td>26</td>
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</table>
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.

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References
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