Mechanical Thrombectomy for Acute Stroke With the Alligator Retrieval Device

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Background and Purpose—Recanalization of occluded vessels in acute ischemic stroke is associated with improved outcome. Devices that can quickly and safely remove thrombus and promote recanalization are useful in the management of these patients. The Alligator retrieval device, developed for endovascular foreign body retrieval, may also be useful for thrombus removal.

Methods—Seven patients with acute ischemic stroke (aged 31 to 88 years) who underwent intra-arterial therapy with the Alligator retrieval device at our center are presented.

Results—The Alligator retrieval device was able to retrieve the thrombus in 5 of 7 cases with good to excellent recanalization seen and was unsuccessful in 2 of 7 patients. Complete recanalization was obtained in one of 7 patients and near complete recanalization obtained in 4 of 7 patients. Three of the 7 patients had good outcome at 3 months and 3 of 7 patients died within 30 days of treatment.

Conclusion—The Alligator retrieval device was successfully able to remove thrombus in the majority of cases. It appears to have increased success in proximal occlusions in relatively straight segments. In properly selected cases, it may be a useful device in intra-arterial stroke management. (Stroke. 2009;40:3784-3788.)

Key Words: acute stroke ■ mechanical thrombectomy ■ retrieval

Cerebral vessel recanalization is an important determinant of outcome in patients with acute ischemic stroke.1 Earlier and complete recanalization improve outcomes substantially, and thus devices that can quickly and safely promote recanalization are extremely valuable in the intra-arterial management of acute ischemic stroke.1-3 The Alligator retrieval device (ARD) has been developed for endovascular foreign body removal but has recently been reported to have been successful in thrombus removal.4-7 We report our center’s initial experience with the ARD in the intra-arterial management of patients with ischemic stroke.

Methods
The ARD (Chestnut Medical Technologies, Menlo Park, Calif) consists of 4 “jaws” at the end of a flexible wire. The device is deployed through a standard 0.021-inch internal diameter microcatheter. The “jaws” are deployed proximal to the targeted occlusion and the microcatheter is advanced around the “jaws” forcing them to close circumferentially and engage the target. The ARD and microcatheter are then removed as a unit along with the target that has been captured within the closed jaws of the device (Figure 1).

At the discretion of the attending interventionist, this device was used in selected acute stroke cases from April 2007 to July 2007. No prespecified inclusion or exclusion criteria were in place for the application of the ARD because this was not a prospective study. A total of 7 patients (ages 31 to 88 years) had the device used during this time period and were included in the current study. The patient characteristics, imaging findings, treatments, and outcomes were analyzed.

Results
The patient characteristics are shown in Table 1. A total of 7 patients were treated with the ARD. Five of the patients were male and 2 patients were female. The mean age of the patients was 58.7 years (range, 31 to 88 years). The initial presenting National Institutes of Health Stroke Scale (NIHSS) score was on average 19.7 (range, 9 to 25). Four patients presented with middle cerebral artery (MCA) occlusions and 3 patients had occlusion of their distal basilar artery. The treatments used and outcomes are shown in Table 2. Six of 7 patients had intra-arterial administration of tissue plasminogen activator and abciximab at the beginning of the procedure. In 5 patients...
Patients 1, 3, 4, 5, and 6), the ARD was used as the initial treatment and was successful in 4 patients (80%). Two patients had basilar artery occlusions that were successfully revascularized; 3 patients had MCA occlusions and the ARD was successful in 2 patients. The one patient who failed the ARD underwent successful stenting with the Wingspan stent (Boston Scientific Corp, Fremont, Calif).

The Alligator retrieval device was able to retrieve the thrombus in 5 of 7 cases and was unsuccessful in 2 of 7 patients. Complete recanalization was obtained in one of 7 patients and near complete recanalization obtained in 4 of 7 patients. Three of the 7 patients had good outcome at 3 months and 3 of 7 patients died within 30 days of treatment.

The ARD retrieval device was able to retrieve the thrombus in 5 of 7 cases and was unsuccessful in 2 of 7 patients. Complete recanalization was obtained in one of 7 patients and near complete recanalization obtained in 4 of 7 patients. Three of the 7 patients died within 30 days of treatment.

The ARD was used successfully in Patient 2 after failed attempted clot retrieval with a L5 Merci retrieval device and percutaneous balloon angioplasty for a basilar occlusion. In Patient 7, the ARD was used unsuccessfully postpercutaneous balloon angioplasty for a patient with a left MCA occlusion.

Three of the 7 patients died within 30 days of the procedure (Patients 4, 5, and 6). The ages of the patients were 73, 88, and 60 years, respectively. The presenting NIHSS scores of these 3 patients were 20, 24, and 24, respectively. All 3 patients had presented with Thrombolysis In Myocardial Ischemia (TIMI) 0 scores and TIMI 2 or 3 flow was restored in all 3.

There was noted to be one hemorrhage (Patient 2). This hemorrhage was not symptomatic. There was no evidence of subarachnoid hemorrhage or vessel perforation on any of the postoperative CT scans.

Representative case examples are shown in Figures 2 through 4.

Discussion

There have been numerous endovascular techniques used in the treatment of acute ischemic stroke. Currently, none of the available devices provide recanalization rates of 100% and frequently multiple techniques must be used to achieve vessel patency. The most important component of using these various devices is the time required to attempt clot removal. At our institution, we used intra-arterial administration of tissue plasminogen activator and abciximab, clot removal with the MERCI retrieval device, percutaneous balloon angioplasty, intracranial stenting with self-expanding intracranial microstents (eg, Wingspan and Neuroform; Boston Scientific), and more recently clot removal with the ARD. At our institution, these modalities are often used in combination to achieve vessel recanalization.

The ARD can be rapidly placed into the occluded vessel and clot removal attempted. In our series, we attempted to use the device in 7 patients and it was successful in 5 patients. Complete recanalization was obtained in one of 7 patients and near complete recanalization obtained in 4 of 7 patients. There are several factors to consider when contemplating the use of the ARD in acute ischemic stroke intervention.

Vessel Angulation: ARD Is Most Effective in Relatively Straight Segments of the Anatomy

The ARD works best in relatively straight vascular segments and as such is maximally effective within the basilar artery and mid-distal M1 segment of the MCA. In these straight segments, the ARD can be deployed and the device and microcatheter can be advanced as a unit to engage and capture the thrombus and which can then be gently retrieved.

In these straight segments, the jaws of the ARD are radially distributed about the circumference of the vessel lumen, presenting a large capture area to the proximal edge of the thrombus. In addition, if the initial attempt to engage the clot is unsuccessful, the ARD can be easily advanced, as a unit, with the microcatheter and a second attempt at capture can be

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Age, Years</th>
<th>Sex</th>
<th>Presenting NIHSS</th>
<th>Duration of Symptoms, Minutes</th>
<th>Intravenous Tissue Plasminogen Activator (0.9 mg/kg)</th>
<th>Etiology of Stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>35</td>
<td>M</td>
<td>25</td>
<td>110</td>
<td>Yes</td>
<td>Patent foramen ovale</td>
</tr>
<tr>
<td>2</td>
<td>64</td>
<td>F</td>
<td>9</td>
<td>120</td>
<td>Yes</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>31</td>
<td>F</td>
<td>16</td>
<td>160</td>
<td>No</td>
<td>Postpartum hypercoagulable state</td>
</tr>
<tr>
<td>4</td>
<td>73</td>
<td>M</td>
<td>20</td>
<td>60</td>
<td>No</td>
<td>Cardiac catheterization</td>
</tr>
<tr>
<td>5</td>
<td>88</td>
<td>M</td>
<td>24</td>
<td>360</td>
<td>No</td>
<td>None</td>
</tr>
<tr>
<td>6</td>
<td>60</td>
<td>M</td>
<td>24</td>
<td>180</td>
<td>No</td>
<td>None</td>
</tr>
<tr>
<td>7</td>
<td>60</td>
<td>M</td>
<td>20</td>
<td>120</td>
<td>No</td>
<td>Lupus anticoagulant</td>
</tr>
</tbody>
</table>
made. Thus, in straight anatomy, multiple attempts at thrombus capture can be made quickly and efficiently (ie, without having to completely remove the ARD and renegotiate the anatomy with a microwire) until successful.

When applied in curved vascular segments (eg, a thrombus with the trailing end within the supraclinoid segment of the internal carotid artery), clot retrieval with the ARD can be more challenging. When deployed along a curve, the jaws of the ARD tend to be distributed along the outer curvature of the bend, presenting less of a capture area to the proximal thrombus. In addition, it is possible during attempts to advance the ARD to engage the thrombus that the jaws could

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**Table 2. Summary of Patients in Which the ARD Was Used During Intra-Arterial Stroke Treatment**

<table>
<thead>
<tr>
<th>Site of Occlusion</th>
<th>Alligator Device Used</th>
<th>Alligator Successful</th>
<th>Other Intra-Arterial Treatments</th>
<th>Initial TIMI Score</th>
<th>Final TIMI Score Post-ARD</th>
<th>Final Angiographic Result</th>
<th>Outcome (3 Months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Right MCA, 2 separate M2/M3 saddle thrombi</td>
<td>First thrombus, 2 mm ARD×1</td>
<td>Yes</td>
<td>IA tPA, IA abciximab</td>
<td>2</td>
<td>3</td>
<td>Near complete recanalization</td>
<td>BI=100, mRS=2, NIHSS=1</td>
</tr>
<tr>
<td></td>
<td>Second thrombus, 2 mm ARD×1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Basilar apex</td>
<td>3-mm ARD×1</td>
<td>Yes</td>
<td>L5 Merci device, angioplasty (Gateway balloon)×2</td>
<td>0</td>
<td>3</td>
<td>Occlusive thrombus at right PCA (P2/P3)</td>
<td>BI=95, mRS=2, NIHSS=4</td>
</tr>
<tr>
<td>3 Basilar apex</td>
<td>ARD×2 5 mm</td>
<td>Yes</td>
<td>IA tPA, IA abciximab, stent (Wingspan)</td>
<td>2</td>
<td>3</td>
<td>Occlusive thrombus in left SCA</td>
<td>BI=100, mRS=1, NIHSS=1</td>
</tr>
<tr>
<td>4 Left MCA (M1)</td>
<td>3-mm ARD×2 4-mm ARD×2</td>
<td>No</td>
<td>IA tPA, IA abciximab</td>
<td>2</td>
<td>3</td>
<td>Complete recanalization</td>
<td>Dead</td>
</tr>
<tr>
<td>5 Basilar apex</td>
<td>3 mm ARD×3 5-mm ARD×2</td>
<td>Yes</td>
<td>IA abciximab, Merci X6</td>
<td>0</td>
<td>3</td>
<td>Complete recanalization</td>
<td>Dead</td>
</tr>
<tr>
<td>6 Left MCA (M1)</td>
<td>3-mm ARD, 4-mm ARD, 5-mm ARD, total of 7 attempts</td>
<td>Yes</td>
<td>IA tPA, IA abciximab</td>
<td>0</td>
<td>2</td>
<td>Occlusion of left MCA (M2) branches</td>
<td>Deceased</td>
</tr>
<tr>
<td>7 Left MCA (M1)</td>
<td>2-mm ARD×1 3-mm ARD×1 4-mm ARD×1</td>
<td>No</td>
<td>IA tPA, IA abciximab, angioplasty (Hyperglide)</td>
<td>0</td>
<td>3</td>
<td>Occlusion left distal superior M2 branch</td>
<td>Discharge to rehabilitation, outcome data not available</td>
</tr>
</tbody>
</table>

IA indicates intra-arterial; tPA, tissue plasminogen activator; PCA, posterior cerebral artery; SCA, superior cerebellar artery; BI, Barthel Index; mRS, modified Rankin Scale.

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**Figure 2.** Patient 1 was a 35-year-old man presenting with acute onset of left-sided weakness and an initial NIHSS score was 25. He received intravenous (IV) tissue plasminogen activator (tPA) at 1 hour 50 minutes postsymptom onset before being transferred to possible intra-arterial (IA) treatment. On arrival, his NIHSS score was 22. CT did not show evidence of a large ischemic stroke. A, Cerebral angiography. A 2-mm Alligator retriever was navigated through a Prowler Plus Select microcatheter (Cordis Inc, Miami Lakes, Fla) into the clot. The clot was engaged by advancing the microcatheter and gentle traction applied under a live roadmap. When the occlusive thrombus was removed, release of contrast was noted. The microcatheter and Alligator were then slowly pulled back and removed while the guide catheter was aspirated. A 2 mm×10-mm clot was retrieved. Repeat angiography showed that all clot was removed from this M2/M3 division. C (arrow). The second thrombus was approached in the same fashion with 4 mg tPA and 4 mg abciximab given and no improvement noted on subsequent angiography. A 2-mm Alligator retriever was navigated into the clot and withdrawn along with the microcatheter with suction on the guide catheter. A 2 mm×4-mm clot was removed. Repeat angiography showed recanalization of both vessels with a small amount of nonocclusive thrombus. E, This intra-arterial treatment was completed by 5 hours postsymptom onset. The patient improved during the course of his hospital stay. His follow-up MRI confirmed a right frontal infarction with mild hemorrhagic transformation. His etiologic workup discovered a patent foramen ovale, which was felt to be responsible for his stroke and thus was subsequently closed. At 3-month follow-up, he has substantially improved with a Barthel Index of 100, modified Rankin Scale (mRS) score of 2, and a NIHSS score of 1.
cause damage to the vessel or engage small perforators or branch vessels arising from the apex of the curve. In these situations, it can be useful to apply a gentle preshaped curve to the ARD before its introduction into the microcatheter. In addition, in these curved segments, if the initial attempt at thrombus retrieval is unsuccessful, the microcatheter–ARD combination will sometimes not negotiate the acute angle required to regain position for a second capture attempt. In these situations, with each unsuccessful attempt, the ARD must be removed and the microcatheter must be manipulated back into position over a microwire. After position has been re-established with the microcatheter, the ARD can be reintroduced and a second attempt at capture retrieval made. These repeated maneuvers can become time-consuming in some cases where multiple attempts are required. Like with any approach to revascularization, after 3 to 4 failed attempts with an appropriately sized ARD, it is unlikely that the device will ultimately be successful. At this point, other techniques should be considered.

**Selection of ARD Size: Larger Sizes Were More Effective**

In this study, we were successful with the initial pass at clot removal with the 2-mm ARD in one patient with multiple M2 to 3 branch occlusions, however, when the 2- and 3-mm ARDs were used in the M1 segment of the MCA or basilar artery attempts at capture and retrieval were typically unsuccessful. As shown in Table 2, most of these cases required multiple ARD sizes and most frequently it was the larger 4- and 5-mm ARDs that were successful. Given this experience, we recommend starting with the larger sizes of the ARD in the basilar artery, internal carotid artery, and M1 segment of the MCA. These larger sizes present a much larger surface area to the proximal edge of the thrombus, increasing the

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**Figure 3.** Patient 3 was a 31-year-old woman who had delivered 10 days previously by caesarean section presented with right-sided weakness and decreasing responsiveness. After transfer to our institution, she was found to have a basilar artery thrombosis on CT angiography. Diagnostic angiography confirmed the presence of a basilar artery thrombus at the basilar apex (TIMI 2). A, Multiple aliquots of abciximab (total of 10 mg) and tissue plasminogen activator (total of 15 mg) were given into the clot. Two attempts were then made with the ARD. B (arrow), The tines of the ARD engaged into the clot. Note the contrast in basilar artery that was simultaneously injected at the time of ARD pull. The clot was known to be engaged because of a release of contrast into the distal posterior B (arrowhead). A large clot was retrieved with the second attempt, re-establishing flow into bilateral posterior cerebral arteries. C, A small residual thrombus remained in the left superior cerebellar artery (TIMI 3). The patient improved postprocedure. Her etiologic workup revealed a patent foramen ovale, which was felt to be the cause of her stroke and was subsequently closed. At 3 months, she had a Barthel Index was 100, modified Rankin Scale score of 1, and a NIHSS of 1.

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**Figure 4.** Patient 5 was an 88-year-old man who developed dysarthria and was found 6 hours later unresponsive. The patient had partial occlusion of the basilar apex and complete occlusion of the left posterior cerebral artery with no distal flow (TIMI 0). A, A 3-mm ARD was advanced up into the clot at the basilar apex, but after withdrawal of the device, no clot was seen. Three milligrams of intraarterial abciximab was given and a second attempt using the 3-mm ARD was performed that was also not successful. A third attempt with the ARD was also unsuccessful. A microcatheter was placed across the thrombus and 2 mg abciximab was infused into the posterior cerebral artery. A Merci X6 retrieval device was then deployed, but no clot was removed. The next attempt was with a 5-mm Alligator, which was deployed simultaneously as contrast was injected. The clot was seen to move but repeat angiography showed the clot remained in the basilar apex. Another attempt was made with a 5-mm Alligator device with simultaneous contrast injection, this time with successful aspiration of the thrombus. B (arrow), The tines of the ARD engaged into the thrombus at the basilar artery apex. Repeat angiography showed complete refilling of the basilar artery and its branches. C, MRI follow-up imaging showed bilateral pontine, midbrain, and thalamic infarction. No clinical improvement was noted several days postevent and thus the family decided for comfort care measures.
likelihood of engagement and capture. The individual jaws of the device are quite delicate and apply very little outward radial force to the vessel wall when deployed. As such, there is little risk associated with starting with the larger devices with most large vessel occlusions.

**Simultaneous Contrast Injection Allows Recognition of Capture During Retrieval**

During our initial applications of the device, we would attempt to engage the clot under roadmap control and then pull the entire ARD and microcatheter out of the guide catheter. If the clot had not been successfully engaged and retrieved, the entire process of manipulating the microcatheter into position for another retrieval attempt would have to be repeated. We noted an increase in the efficiency of clot retrieval when we tested for clot capture by injecting contrast under a live roadmap during the initial part of the ARD–microcatheter withdrawal. When the clot had been successfully engaged and retracted by the ARD, the contrast trapped behind the occlusion would release into the distal vessel representing displacement of the occluding thrombus with subsequent revascularization. In addition, it is often possible to see the captured clot within the jaws of the ARD as a lucent filling defect within the column of contrast material. When there was no contrast release distally, the microcatheter would simply be advanced back over the distal tines of the ARD and driven back toward the clot for another retrieval attempt. In straight anatomy, numerous attempts to engage the clot can be made in a very short period of time (<5 minutes) until one achieves an effective capture that allows retrieval.

**Full ARD Deployment Before Clot Engagement Facilitates Thrombus Capture**

During attempted capture, it was important to fully deploy the ARD within the patent vessel proximal to the thrombus and allow the jaws to fully open before attempts at thrombus capture. In this configuration, the largest possible capture surface area is presented to the thrombus when the device is advanced. Then, when advanced to the leading edge of the thrombus, the ARD jaws can be closed circumferentially around the periphery of the proximal edge, maximizing the likelihood of capture. When the device was deployed partially inside of the thrombus, the jaws often would not completely open, and attempts to engage the thrombus were always unsuccessful.

**Conclusion**

The ARD can be used as the initial device for intra-arterial stroke treatment or as a salvage technique. The performance of the ARD is optimized in straight vascular segments. Simultaneous contrast injection during attempted retrieval can verify clot capture and maximize the efficiency of the revascularization procedure.

**Disclosures**

M.E.K. is a consultant for Micrus Endovascular (less than $10 000). P.A.R. is a shareholder in Chestnut Medical Technologies. D.F. is a shareholder in Revasc Inc (acquired by Micrus Endovascular); received grant support of more than $10 000 from Boston Scientific; and honoraria and consulting fee of less than $10 000 from Boston Scientific, Cordis, and Micrus Endovascular.

**References**

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