

## Management of acute basilar artery occlusion: Should any treatment strategy prevail?

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**Background.** Acute basilar artery occlusion (BAO) is relatively infrequent form of acute ischemic stroke associated with severe and persisting neurological deficit and high mortality rate (to 86%). Early recanalization is essential for good clinical outcome but the most effective treatment approach remains unestablished. Several treatment strategies are currently available but their safety and efficacy have only been tested in retrospective/prospective case series. Randomized controlled trials (RCTs) are lacking.

**Methods and Results.** We searched the PubMed database for assessments of recanalization rate and clinical outcome in BAO patients treated with various treatment methods. The results show that antithrombotics are least effective while specific reperfusion therapies including intravenous thrombolysis (IVT) and various types of intra-arterial therapy (IAT) are more so. Less than half of BAO patients reach independent outcome following IVT with a recanalization rate 52 - 78%. Even though IAT recanalizes BAO more frequently (in up to 100%), the higher recanalization rate is not necessarily associated with better outcome.

**Conclusions.** Good clinical outcome is strongly dependent on recanalization time. Thus, the concept of bridging therapy, combining widely available IVT with IAT, was introduced and is usually considered a rescue strategy in non-responders to IV alteplase. A trend to better outcome in patients treated with bridging therapy in some studies, has to be confirmed by large RCTs.

**Key words:** ischemic stroke, basilar artery, occlusion, treatment method, recanalization, outcome

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### INTRODUCTION

Acute basilar artery occlusion (BAO) is associated with severe and persistent neurological deficit and high mortality rate. If untreated, the mortality rate can be as high as 86% (ref.<sup>1,2</sup>). This is also the reason why good clinical outcome, in contrast to the anterior circulation, was defined as a value of 0–3 points in the modified Rankin Scale (mRS) in the majority of studies. Poor clinical outcome is associated more frequently with occlusion of proximal and middle segments<sup>3</sup> while length of BA occlusion and state of collaterals are additional independent variables affecting survival<sup>4,5</sup>.

Early recanalization is a strong predictor of good BAO outcome<sup>6</sup>, but the most effective therapeutic approach has not been established, yet. Currently, several treatment approaches are available: antithrombotic treatment (AT), intravenous thrombolysis (IVT), intra-arterial treatment (IAT - including intra-arterial thrombolysis, endovascular sonolysis and mechanical thrombectomy) or combinations of these.

According to the European Stroke Organisation (ESO) guidelines, intra-arterial (IA) thrombolysis is recommended for acute BAO in selected patients. IVT for BAO is an acceptable alternative even after 4.5 h of onset of symptoms<sup>7,8</sup>. Even though the time window is

not as strict as it is for anterior circulation, shorter time to recanalization in BAO is associated with a more favorable outcome while poor outcome is more likely when recanalization therapy is started more than 6 hours after estimated time of BAO (ref.<sup>6</sup>).

### Nonspecific Treatment

Standard nonspecific treatment includes the administration of either antiplatelet drugs, anticoagulation therapy, or their combination. In BAO, antithrombotics are mostly considered ineffective. After the first case series published in the early 1970's (ref.<sup>9</sup>) Archer et al. presented 20 patients treated with either antiplatelets or anticoagulants and they had a mortality rate of 70% (ref.<sup>1</sup>).

Since then, few case reports of patients initially presenting with a severe deficit and substantially improving after nonspecific treatment have been published<sup>10,11</sup> however, hospital-based series report case fatality up to 86% (ref.<sup>1,2,9,12</sup>). As all of these studies were too small to provide solid data, the sample of 82 patients presented by Schonewille et al. provided more accurate data: mortality 40% and dependency among survivors 65% (ref.<sup>13</sup>). Even though these patients were treated during the time period when thrombolysis was not standard, they were not consecutively pooled out. Eleven patients were excluded because of the intravenous (IV) and IA use of

thrombolysis, meaning selection bias could play a role as a confounding factor. Moreover, BAO was confirmed only in 30% of these patients. To date no direct comparison has been made between AT and placebo, or comparison between different types of antiplatelet drugs administered solely without any additional therapy (i.e. IVT, IAT, ...).

In the Basilar Artery International Cooperation Study (BASICS) registry<sup>14</sup>, 66/183 (36.1%) patients treated with AT had good functional outcome (mRS 0-3) after 1 month. In comparison, AT group patients presented with milder neurological deficit in the National Institutes of Health Stroke Scale (NIHSS) (mean 15 points) at the time of treatment than patients in the IVT (mean 21 points) and IAT (mean 25 points) group.

Table 1 shows clinical outcome in BAO patients treated with AT from different studies.

### Intravenous Thrombolysis

IVT, which is widely accessible, is considered standard specific reperfusion therapy in acute ischemic stroke. It can be used prior to transport as bridging in terms of "drip, ship and retrieve protocol" referred earlier by Pfefferkorn et al. as a feasible treatment approach<sup>15</sup>.

The only drug approved by the European Medicines Agency (EMA) for the treatment of ischemic stroke is recombinant tissue plasminogen activator (rt-PA) (ref.<sup>16</sup>). Randomized trials show that patients might benefit from IVT up to 4.5 h after symptom onset<sup>17</sup>. It is known that risk might outweigh benefit beyond 4.5 h in the anterior circulation. Given that BAO is a rare form of stroke, individuals, suffering from BAO, have barely influenced study. According to the ESO guidelines, IVT for BAO is an acceptable alternative even after 4.5 h after the onset of symptoms<sup>6,7</sup>.

Several studies reported the efficacy of IVT similar to invasive endovascular therapy reaching good clinical outcome, defined as mRS 0 - 2 in 21-53% and as mRS 0 - 3 in 26-63% (Table 2) (ref.<sup>14,18-21</sup>). The largest single center cohort study from Helsinki comprised 116 patients mostly treated with IVT (ref.<sup>20</sup>). Thirty (26%) of these had good 3-month clinical outcome while 48 (41%) died. Sairanen et al. achieved recanalization in 65% of IVT patients, reaching the efficacy of local IAT that varied with different endovascular technique between 62.5 and 94% (ref.<sup>14,22-25</sup>). In a systematic analysis comparing IVT and IAT (ref.<sup>19</sup>) recanalization rate was higher in the IAT

**Table 1.** Outcome in conventionally treated patients.

Study	Year	n	modified Rankin Scale		Mortality (%)
			0 - 3 (%)	4 - 5 (%)	
Moscow <sup>9</sup>	1973	9	44	22	33
Archer <sup>1</sup>	1977	20	5	25	70
Hacke <sup>2</sup>	1988	22	14	0	86
Devuyst <sup>12</sup>	2002	9	66	22	11
Schonewille <sup>13</sup>	2005	82	21	39	40
BASICS - MtM <sup>14</sup>	2009	104	58	30	13
BASICS - S <sup>14</sup>	2009	79	8	38	54

BASICS - Basilar Artery International Cooperation Study; MtM - mild to moderate deficit; n - number; S - severe deficit

**Table 2.** Outcome in patients treated with IVT.

Study	Year	n	modified Rankin Scale			Mortality (%)	Time of follow-up	SICH (%)	Recanalization rate (%)
			0-2 (%)	0-3 (%)	4-5 (%)				
Lindsberg <sup>18</sup>	2004	50	22	32	28	40	3 months	14	52
		50	30	34	20	46	1 year		
Lindsberg, Mattle* <sup>19</sup>	2006	76	22	N/A	N/A	50	varies	11	53
BASICS - MtM <sup>14</sup>	2009	49	53	63	20	16	1 month	6	71
BASICS - S <sup>14</sup>	2009	72	21	26	28	46	1 month	6	66
Sairanen <sup>20</sup>	2011	116	26	36	22	41	3 months	16	65
Miyagi <sup># 21</sup>	2012	25	48	N/A	N/A	4	3 months	8	78

BASICS - Basilar Artery International Cooperation Study; MtM - mild to moderate deficit; n - number; S - severe deficit; SICH - symptomatic intracranial hemorrhage

\* systematic review of literature up to 2005

# patients treated with low-dose alteplase (0.6 mg/kg)

group (65%) than in the IVT group (53%). There was hardly any chance of favorable clinical outcome for those without recanalization (2%), but 38% when achieving at least partial recanalization. However despite these facts, higher recanalization rate was not automatically associated with better clinical outcome.

In the BASICS registry<sup>14</sup> patients with mild to moderate deficit had similar risk of poor outcome after IVT or AT but presented with better outcome after IVT in comparison with IAT. Patients with severe deficit (coma, locked-in state, tetraplegia) had lower risk of poor outcome after IVT against AT group, but similar when compared to IAT.

A standard dose of rt-PA is 0.9 mg/kg body weight (maximum 90 mg), with 10% of the dose given as a bolus followed by a 60-minute infusion. The therapeutic efficacy of low-dose IV alteplase for BAO remains unknown. When comparing 25 patients with BAO and patients suffering from the middle cerebral artery (MCA) occlusion in a Japanese multicenter registry involving 600 stroke patients treated with low-dose (0.6 mg/kg) alteplase, similar occurrence of symptomatic intracranial hemorrhage (SICH) within the initial 36 h (8 vs. 5%), independence at 3 months (mRS score 0 - 2; 48 vs. 52%), and mortality rate at 3 months (4 vs. 6%) was found<sup>21</sup>. When compared to previous publications with BAO patients<sup>14,18-20</sup> the resulting clinical outcome was better with less SICH but the

number of patients was too small to reach any conclusion. There also exists a case report of a patient with basilar artery stenosis prior to distal BAO treated 3 days after symptoms (vertical gaze palsy, spontaneous nystagmus, and gait ataxia) onset with low-dose IV administration of 0.125 mg/kg rt-PA that was continuously infused for 48 h resulting in favorable clinical outcome (mRS 0) (ref.<sup>26</sup>).

### Intra-arterial Thrombolysis

Intra-arterial thrombolysis is the direct introduction of fibrinolytics into the clot at the site of the arterial occlusion through a microcatheter resulting in a local concentration of fibrinolytics high enough to break up the clot while maintaining low systemic concentration to prevent adverse effects and to assess vessel patency and collateral flow. The safety and efficacy of this method was confirmed in the Prolyse in Acute Cerebral Thromboembolism II (PROACT II) trial, the first randomized control trial (RCT) comparing IA thrombolysis with placebo in patients with acute ischemic stroke caused by MCA occlusion<sup>27</sup>.

The first experience with IA thrombolysis (using streptokinase) in patients with vertebrobasilar thromboembolic disease was reported by Zeumer et al in 1983 (ref.<sup>28</sup>). Since then, multiple case series were published presenting clinical outcome in patients treated with IA thrombolysis<sup>2,4,5,24,25,29-35</sup> (see Table 3). It is impossible to

**Table 3.** Outcome in patients treated with intra-arterial thrombolysis.

Study	Year	n	modified Rankin Scale			Mortality (%)	Time of follow-up	Agent	SICH (%)	Recanalization rate (%)
			0-2 (%)	0-3 (%)	4-5 (%)					
Hacke <sup>2</sup>	1988	43	N/A	23	7	70	discharge	U, ST	9.3	44
Brandt <sup>4</sup>	1996	51	20	29	2	69	N/A	U, rt-PA	0	51
Cross <sup>5</sup>	1998	24	25	33	4	63	3 months	U	N/A	N/A
Eckert <sup>30</sup>	2002	83	23	N/A	17	60	3 months	U, rt-PA, rt-PA + L-P	N/A	66
Arnold M <sup>29</sup>	2004	40	35	N/A	N/A	42	3 months	U	5	80
Lindsberg <sup>*19</sup>	2006	344	24	N/A	31	55	N/A	varies	8	65
Schulte <sup>32</sup>	2006	180	23	N/A	N/A	43	discharge	U, ST, rt-PA	30	74
Smith <sup>#34</sup>	2007	316	N/A	N/A	N/A	56	N/A	varies	7	64
BASICS - MtM <sup>14</sup>	2009	92	30	43	34	23	1M	varies	14	83
BASICS - S <sup>14</sup>	2009	196	11	17	34	49	1M	varies	14	69
Yu <sup>25</sup>	2010	52	42	N/A	N/A	39	discharge	U, rt-PA	12	77
Jung <sup>24</sup>	2011	106	33	44	15	41	3 months	U with on-demand endovascular mechanical recanalization	1	70
Chandra <sup>33</sup>	2011	40	35	50	17	33	3M	U, H with on-demand endovascular approach	13	83

BASICS - Basilar Artery International Cooperation Study; H - heparin; L-P- lys-plasminogen; MtM - mild to moderate deficit; n - number; N/A - not available; rt-PA- recombinant tissue plasminogen activator; S - severe deficit; SICH -symptomatic hemorrhages; ST - streptokinase; U - urokinase  
\* systematic review of literature up to 2005

# meta-analysis

reliably compare the findings of these uncontrolled series, because they differ in method and timing of follow up, patient baseline characteristic, time-to-treatment and use of different drugs. The largest of these studies pooled out 180 patients treated with either urokinase or streptokinase from five German stroke centers with an overall mortality of 43% (ref.<sup>33</sup>). Complete recanalization was achieved in 99 (55%) patients and partial recanalization in 35 (19%) patients. Favorable outcome was strongly associated with maintenance of vessel patency ( $P<0.001$ ) which supports the idea that recanalization is essential for good clinical outcome.

Recanalization therapy of BAO by thrombolytics is not based on the results of RCTs. To date, only one RCT was carried out, comparing IA urokinase and anticoagulation within 24 h from symptom onset<sup>36</sup>. Good clinical outcome was observed in 4 out of the 8 patients who received IA urokinase compared with 1 out of the 8 patients in the control group. Nevertheless, the set of patients (16) was too small with imbalances in treatment groups (severe patients were more often allocated to the IA thrombolysis group) to give any reliable management recommendation.

In 2007, a large meta-analysis of 10 studies including 316 BAO patients treated with IA thrombolysis was performed by Smith et al.<sup>35</sup>. In this meta-analysis, an overall 64% recanalization rate, 7% ICH occurrence and 56% mortality (significantly lower in recanalized patients versus those without recanalization, 37% versus 87%, leading to significant 48% absolute risk reduction of death with successful recanalization;  $P<0.001$ ) were reported. Similar results were presented by Lindsberg et al.<sup>19</sup> in the systematic review including 344 patients, out of whom 55% died, but 23% reached good clinical outcome (mRS 0 - 2). Recanalization was successful in 65% of patients and the occurrence of SICH was 8% in this review.

Different agents have been used for IA thrombolysis, e.g. streptokinase, alteplase, reteplase, urokinase and heparin. Direct comparison of different fibrinolytic agents used for IA thrombolysis is lacking, with the exception of a retrospectively collected set of 55 patients with large vessel occlusion, of whom 33 were treated with reteplase and 22 with urokinase<sup>37</sup>. Eighteen suffered from BAO and it was found that IA thrombolysis with reteplase did not significantly differ in recanalization, outcome, mortality or ICH occurrence compared to IA urokinase or IA pro-urokinase.

### Mechanical Thrombectomy

Early recanalization has a major influence on clinical outcome in BAO. Thus, new approaches have been studied to achieve and maintain BA patency. Several devices have been developed to enable mechanical clot extraction. Besides BAO, other large vessels (internal carotid artery, MCA) occlusions were usually included in the majority of existing studies.

The MERCI (Mechanical Embolus Removal in Cerebral Ischemia) retriever® (Concentric Medical, Mountain View, CA, USA) was the first mechanical device approved by the FDA. This retriever, constructed of nitinol memory-wire, is delivered to the lesion location in

its linear formation. Once deployed, it returns to its coiled shape to engage the clot, then pulled back-ward to the tip of the catheter through which it is aspirated. Lutsep et al.<sup>38</sup> analyzed data on vertebrobasilar occlusion from MERCI and Multi-MERCI trials. Patients, all treated within 8 h from symptom onset, reached good clinical outcome in 41%. Recanalization was found in 21 out of the 27 (78%) patients and patients with successful recanalization tended to have better outcomes. Mortality was 44%. When comparing patients ( $n=305$ ) with failed IV rt-PA versus non-IV rt-PA patients, all treated with MERCI® catheter, similar rates of good outcomes, a tendency toward lower mortality, and similar revascularization rates were found in the failed IV rt-PA group<sup>39</sup>. Vertebrobasilar occlusion was represented by 25 (non-IV rt-PA) and 3 (failed IV rt-PA) patients. Good clinical outcome was found in 28% and 66% at 3 months with recanalization rate of 76% and 100%, resp.

The Penumbra system® (Penumbra Inc., Alameda, CA, USA) works by advancing a reperfusion catheter over a neurovascular guide wire at the site of the thrombus. An appropriately sized separator is advanced and retracted through the catheter to dislodge the clot and a suction device grabs the clot for removal. The Penumbra® pivotal stroke trial that led to its approval by the US FDA showed 82% recanalization rate, 11% SICH occurrence and, 25% of patients achieving good clinical outcome (mRS 0 - 2) (ref.<sup>40</sup>). However, only 11 patients with vertebrobasilar occlusion were enrolled to this study. Even better results were reported by Hussain et al., on 157 patients with large vessel occlusion and reaching favorable clinical outcome (mRS 0 - 2) in 41% (ref.<sup>41</sup>). Future studies are needed to assess its efficacy in the BAO.

Stent retrievers have become dominant in the last few years. The Solitaire system (Solitaire™ AB and FR, ev3 Inc., Irvine, CA, USA) is based on self-expanding retrievable intracranial stent that is used at the site of the thrombus, withdrawn, and removed with the clot. Mattle et al.<sup>42</sup> reviewed three pilot studies with a total of 29 patients with BAO and reported at least 90% recanalization rate, 31% mortality rate and 45% favorable outcome (mRS 0 - 2) among survivors. However, these trials differed in the proportional representation of BAO and pre-post-Solitaire™ treatment method and proportion<sup>43,45</sup>. In a recent study, Mordasini et al. presented 14 consecutive patients with BAO treated with Solitaire™ with on demand addition of multimodal therapy approaches, such as for example thromboaspiration, IV and/or IA thrombolysis, and percutaneous transluminal angioplasty/permanent stent placement<sup>45</sup>. At 3 months, good functional outcome (mRS 0 - 2) was observed in 28.6% (4/14) patients and overall mortality was 35.7% (5/14). Hemorrhagic complications were referred in up to 3% of BAO patients undergoing mechanical clot extraction<sup>43,47</sup>. Although Solitaire™ may be used as the first line treatment, difficult situations can arise subsequently requiring additional procedures such as permanent stent or balloon angioplasty<sup>46,48</sup>. In the randomized SWIFT trial that included 113 patients treated within 8 h from symptom onset (2% with the occlusion in posterior circulation), the Solitaire Flow Restoration

Device<sup>TM</sup> achieved better angiographic, safety, and clinical outcomes than did the Merci Retrieval System<sup>®</sup> (ref.<sup>49</sup>).

### Endovascular Sonolysis

The EKOS<sup>®</sup>MicroLysUS infusion catheter (EKOS Corporation, Bothell, WA, USA) is a standard microinfusion catheter with a ring sonography transducer at its distal tip that generates a 360° circumferential pulse wave around the distal tip. The catheter is designed to be used in conjunction with IA thrombolytic infusion. Ultrasound delivers mechanical pressure waves to the clot, thus exposing more thrombus surface to thrombolytic drug reducing treatment time and total lytic dose delivered. EKOS<sup>®</sup> proved to be feasible method in the management of acute stroke<sup>50,52</sup>. Kuliha et al. compared 7 BAO patients undergoing EkoSonic endovascular sonolysis with controls showing significant reduction in mortality rate (0 vs. 66.7% of patients,  $P=0.013$ ) (ref.<sup>53</sup>). The efficacy in BAO still remains to be clarified and comparison with other endovascular techniques is also needed.

### Bridging Therapy

Bridging therapy is a therapeutic approach that uses IVT with subsequent IA thrombolysis or endovascular mechanical therapy, or both. It combines the speed of widely accessible IV agents such as alteplase (mostly in a dose of 0.6 to 0.9 mg/kg) (ref.<sup>39,54,55</sup>) or glycoprotein IIb/IIIa inhibitors abciximab and tirofiban, with a high recanalization rate of endovascular techniques<sup>14,24,44,46</sup>. Despite published data from 2 meta-analyses supporting bridging therapy as a therapeutic approach in patients with large vessel occlusion<sup>56,57</sup> recent studies report no significant difference in functional outcome between bridging and IVT alone and endovascular treatment alone<sup>58,59</sup>.

Georgiadis et al. compared IVT vs. combination of IV and IA thrombolysis in his meta-analysis comprising 11 studies with a total of 457 patients<sup>57</sup>. One hundred and forty patients in 4 studies received 0.9 mg/kg of IV rt-PA while 317 patients in 7 studies received 0.6 mg/kg. Patients in the 0.9 mg/kg group had higher rates of favorable outcome ( $P=0.022$ ) and similar rates of SICH ( $P=0.70$ ). In the meta-analysis performed by Mazighi et al.<sup>56</sup> and including 559 patients in 15 studies, no difference in recanalization, functional outcome, SICH occurrence or mortality was found between the 2 dosages. Recanalization rate was 69.6%, SICH occurrence 8.6%, 48.9% of patients reached favorable outcome whereas 17.9% of them died. Shorter time to IV treatment improved both the recanalization rate and the mortality rate. These meta-analyses were limited by variability in both patient population and IA techniques. Additionally, the majority of patients (63% on average) presented with MCA occlusion.

In the Interventional Management of Stroke (IMS) III trial, 656 patients were randomized, 434 patients to IVT + endovascular therapy and 222 to IVT alone<sup>59</sup>. The proportion of patients with favorable outcome (mRS 0 - 2) at 90 days did not differ significantly according to the treatment (40.8% with IVT + IAT and 38.7% with IVT), with similar mortality rate (19.1 vs. 21.6%;  $P=0.52$ ) and the proportion of patients with SICH (6.2 vs. 5.9%;  $P=0.83$ ). In the

first phase of this trial, including 284 patients, computed tomography angiography was used infrequently, and patients with NIHSS  $\geq 10$  were included only with an assumption of the major arterial occlusion. Stent retrievers were used in only a small number of patients. In addition, only 4 patients with BAO were included. Mean time to groin puncture was 86 min and mean time from groin to IAT was 44 min. In the IMS III trial, time to endovascular therapy was longer than in IMS I and IMS II trials despite great emphasis on time. Kass-Hout et al. demonstrated similar outcome, revascularization rate, SICH occurrence, and mortality rate in 106 patients treated either by IVT + IAT or IAT alone<sup>58</sup>. Nevertheless, the endovascular group was treated significantly earlier than the combined group (125 $\pm$ 40 vs. 227 $\pm$ 88 min;  $P<0.0001$ ). Based on these meta-analyses it seems that additional IA approach probably should be started as soon as possible and not considered only as a rescue strategy<sup>56</sup>.

Pfefferkorn showed the feasibility of “drip, ship and retrieve” strategy in 52 BAO patients<sup>15</sup>. Patients undergoing full-dose IVT with a subsequent IAT ( $n=26$ ) achieved good 90-day clinical outcome (mRS 0 - 2) more frequently than those ( $n=26$ ) treated with primary IAT with or without bridging with tirofiban (38 vs. 12%;  $P=0.03$ ). Bridging with abciximab prior to IAT application of rt-PA in BAO patients was tested in two other studies reaching favorable clinical outcome (mRS 0 - 3) in 34.9 and 15%, resp. with recanalization rate 83.7 and 85%, resp.<sup>22,60</sup>. Compared to the group treated with IA rt-PA only, higher recanalization rate (83.7 vs. 62.5%;  $P=0.03$ ), higher survival rate (58.1 vs. 25%;  $P=0.01$ ), and larger number of patients with favorable outcome (mRS 0-3; 34.9 vs. 12.5%;  $P=0.02$ ) were observed in the bridging group.

In our recent retrospective study<sup>61</sup> of 50 patients, four treatment groups were compared: 1) bridging group (IVT + IAT), 2) IAT only, 3) IVT only, and 4) AT only. Successful recanalization was achieved in 94.1% IAT patients, 8.3% IVT patients, and 92.3% IVT + IAT patients, while no patient from the AT group recanalized. Recanalization rate was significantly higher in patients who achieved favorable (91.7%) vs. poor (47.4%) clinical outcome ( $P=0.008$ ). An apparent trend for better outcome was found in the bridging group, however, results in particular treatment groups were not statistically significantly different.

### CONCLUSION

Acute BAO is associated with severe and persistent neurological deficit, high mortality rate and its early recanalization is substantial. However, higher recanalization rate is not necessarily associated with better outcome. Currently, several treatment methods are available, including combinations and bridging approaches. A trend for better outcome in patients treated with bridging therapy in some studies, has to be confirmed by large RCTs. It seems that additional IA approach should be started as soon as possible and not considered only as a rescue strategy.

## ABBREVIATIONS

AT, Antithrombotic treatment; BA, Basilar artery; BAO, Basilar artery occlusion; BASICS, Basilar Artery International Cooperation Study; EMA, European Medicines Agency; ESO, European Stroke Organisation; IA, Intra-arterial; IAT, Intra-arterial treatment; IMS, Interventional Management of Stroke; IV, Intravenous; IVT, Intravenous thrombolysis; MERCI, Mechanical Embolus Removal in Cerebral Ischemia; MCA, Middle cerebral artery; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; rt-PA, recombinant tissue plasminogen activator.

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