Imperial College London

PRESTIGE-AF
PREVENTION OF STROKE IN INTRACEREBRAL HAEMORRHAGE SURVIVORS WITH ATRIAL FIBRILLATION

NHS Imperial College Healthcare NHS Trust

La patologia del circolo vertebro-basilare

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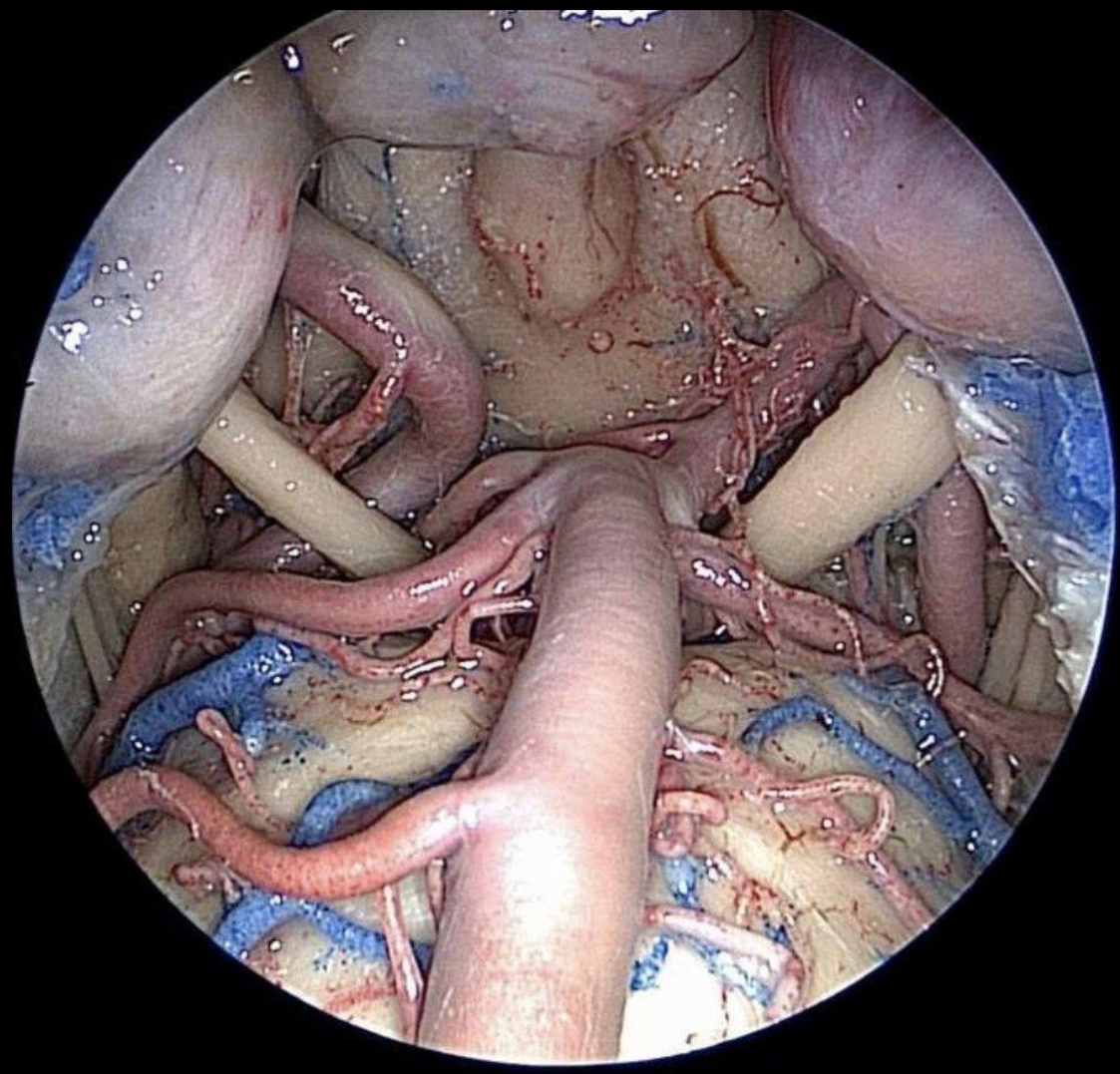
Lucio D’Anna reports no disclosure

Outline

- Natural History of BAO
- Pathophysiology of BAO
- Imaging Selection
- BASICS prospective registry
- BASICS and BEST RCT
- ATTENTION AND BOACHE RCT
- Pre-hospital system of care in BAO
- Take home message

L’arteria basilare

- Basilar artery occlusion (BAO) accounts for about 1% of all strokes and is reported in about 8% of patients with symptomatic vertebrobasilar territory ischaemia;
- Incidence of BAO to be about one patient per 100 000 a year,
- Patients are usually elderly, but younger people or even children can have BAO



Endoscopic view of the basilar artery and the floor of the third ventricle

Local Intraarterial Thrombolysis in Vertebrobasilar Thromboembolic Disease

H. Zeumer,[1] W. Hacke,[2] and E. B. Ringelstein[2]

The poor prognosis of basilar artery occlusion is well known. Systemic anticoagulation rarely prevents a lethal outcome. A new therapeutic approach involves selective perfusion of streptokinase through the vertebrobasilar artery via a coaxial catheter system. Three of five reported cases demonstrated successful vascular recanalization with clinical improvement.

Between 1976 and 1981, 17 patients with angiographically diagnosed basilar artery thrombosis were treated at our clinic. Ten patients died within 2 weeks, while six patients survived more than 6 weeks but less than 3 months. Only one patient survived a 1 year period. All the patients had severe neurologic deficits and died from

The dose of streptokinase (200,000 IU) used in our first four cases was comparable to doses used by cardiologists; however, we administered the drug more slowly. When performing coronary artery thrombolysis, one must take into consideration the great loss of streptokinase to the aortic arch. In comparison, the leakage that takes place in the vertebrobasilar system is less significant. In view of our recent experience using lower doses (50,000 IU) of streptokinase, we are no longer sure that the initial dose of 200,000 IU over a period of 2 hr is either the optimal amount or the best time course for administration of the drug. The fibrinolytic therapy is accompanied by low-dose heparin treatment calculated to prolong thrombin time by a factor of 2 or 3.

AJNR May/June 1983

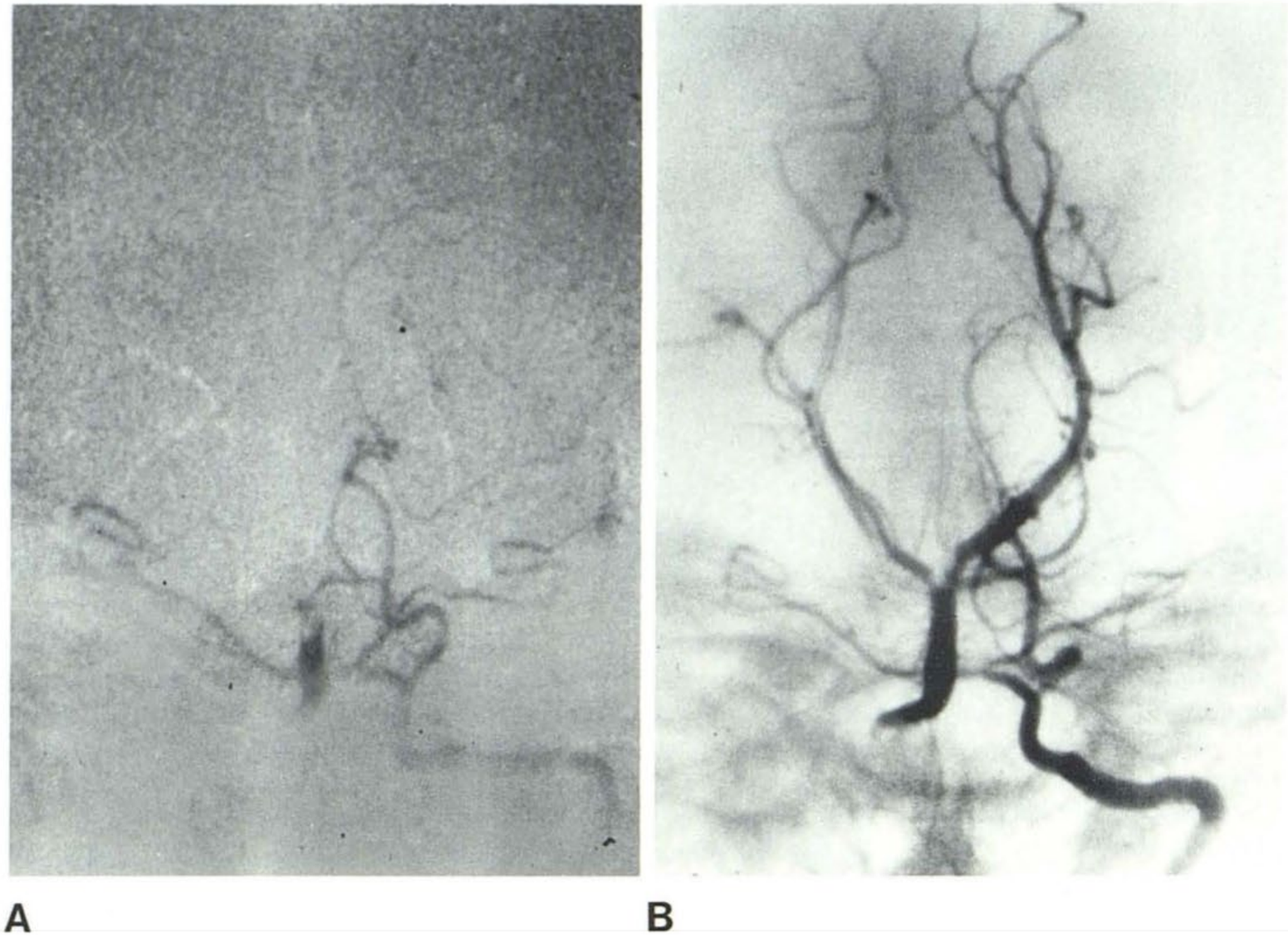


Fig. 1.—Case 1. **A,** Subtotal upper basilar artery occlusion. **B,** Recanalization after local intraarterial fibrinolysis.

17 patients with basilar artery thrombosis treated (1976-1981)

- **10 died (within 2 weeks)**
- **6 survived (> 6 weeks but < 3 months)**
- **1 survived a 1-year period**

All had severe neurologic deficits and died from secondary complications such as PE, MI or pneumonia

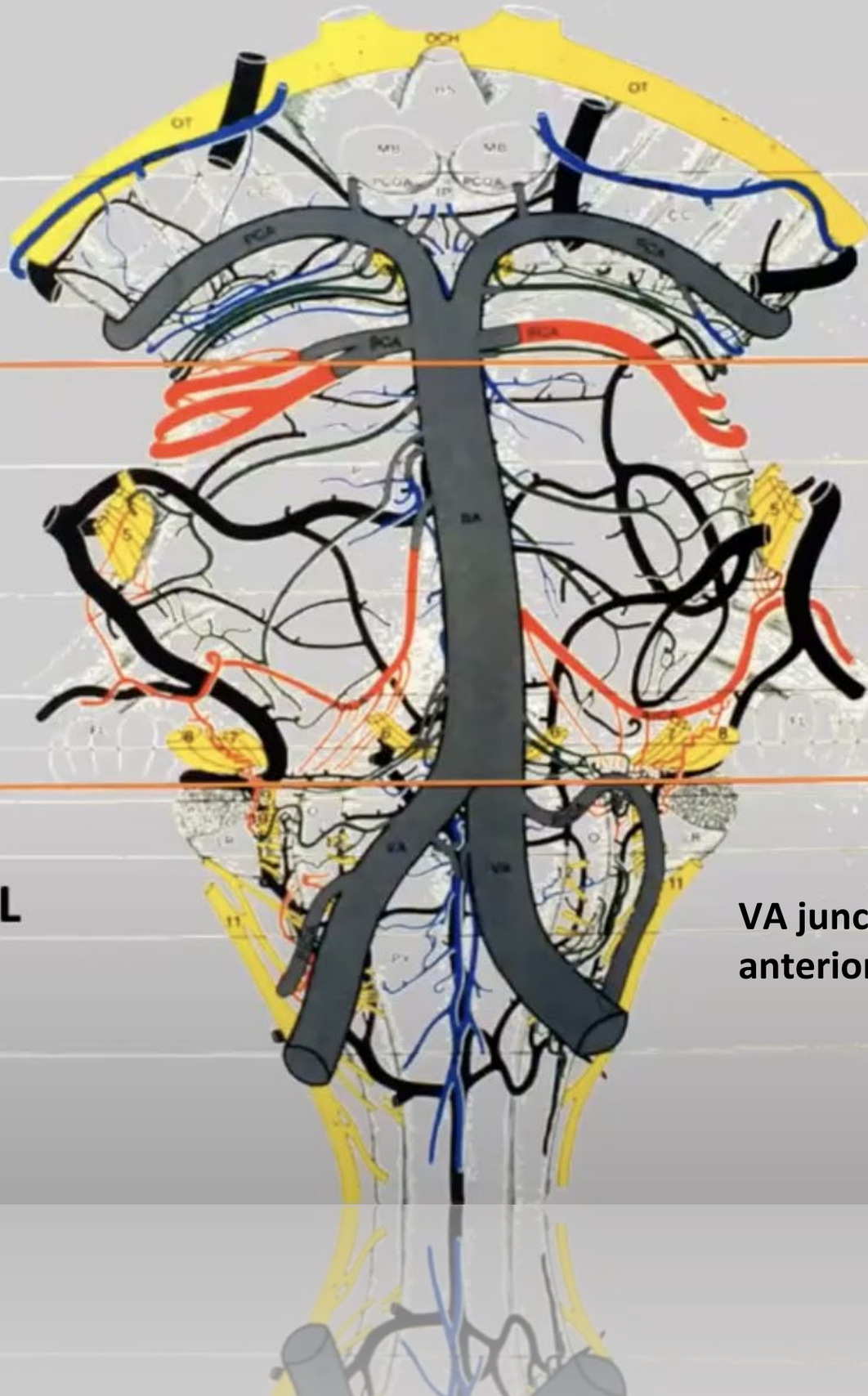
Heparin and other anticoagulants offered no therapeutic advantage

DISTAL

Above superior cerebellar artery

MIDDLE

anterior inferior cerebellar artery - superior cerebellar artery



PROXIMAL

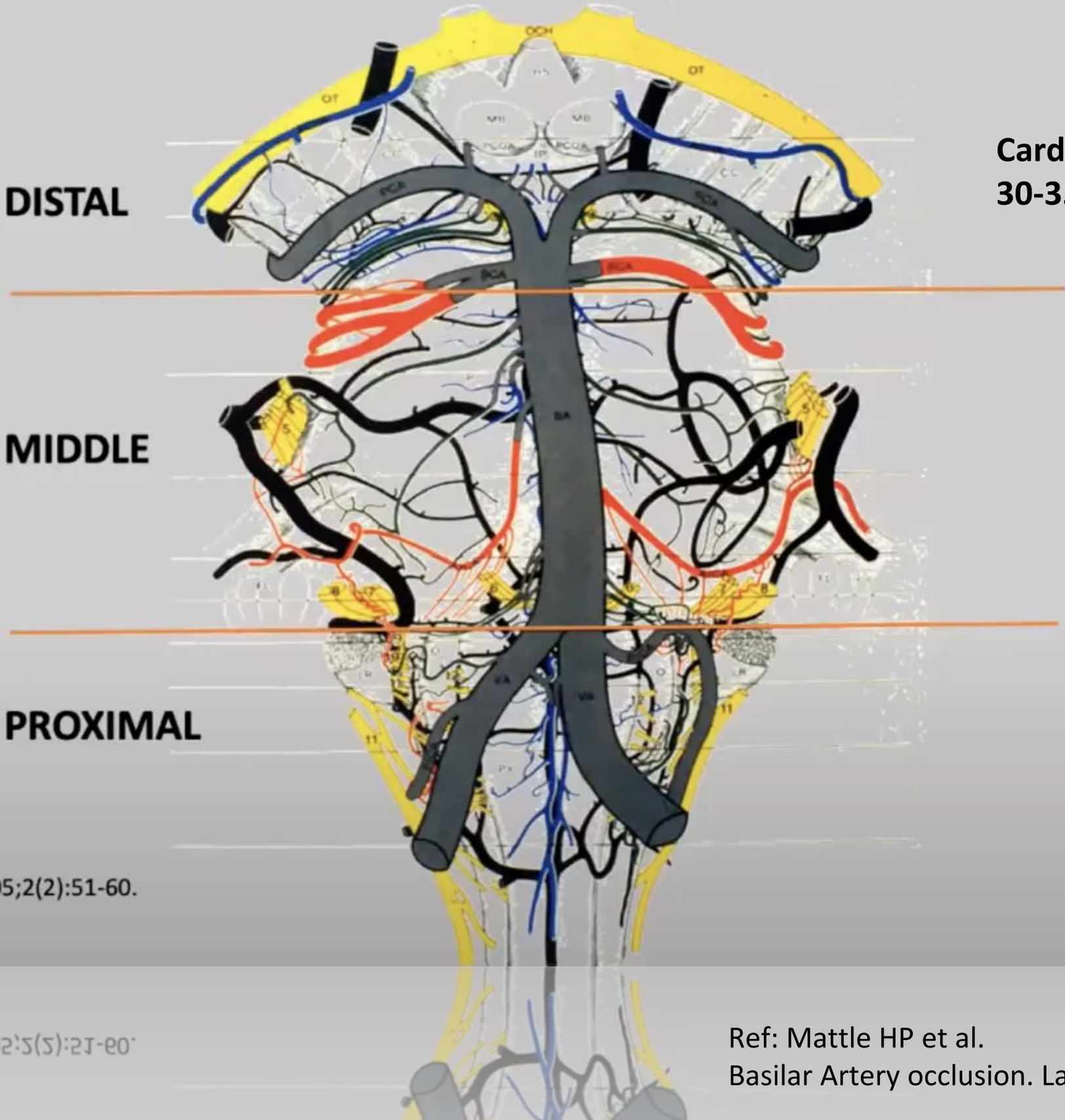
VA junction -
anterior inferior cerebellar artery

Adapted from
Caplan LR. *Rev Neurol Dis*. 2005;2(2):51-60.

DISTAL

MIDDLE

PROXIMAL



Cardioembolic
30-35%

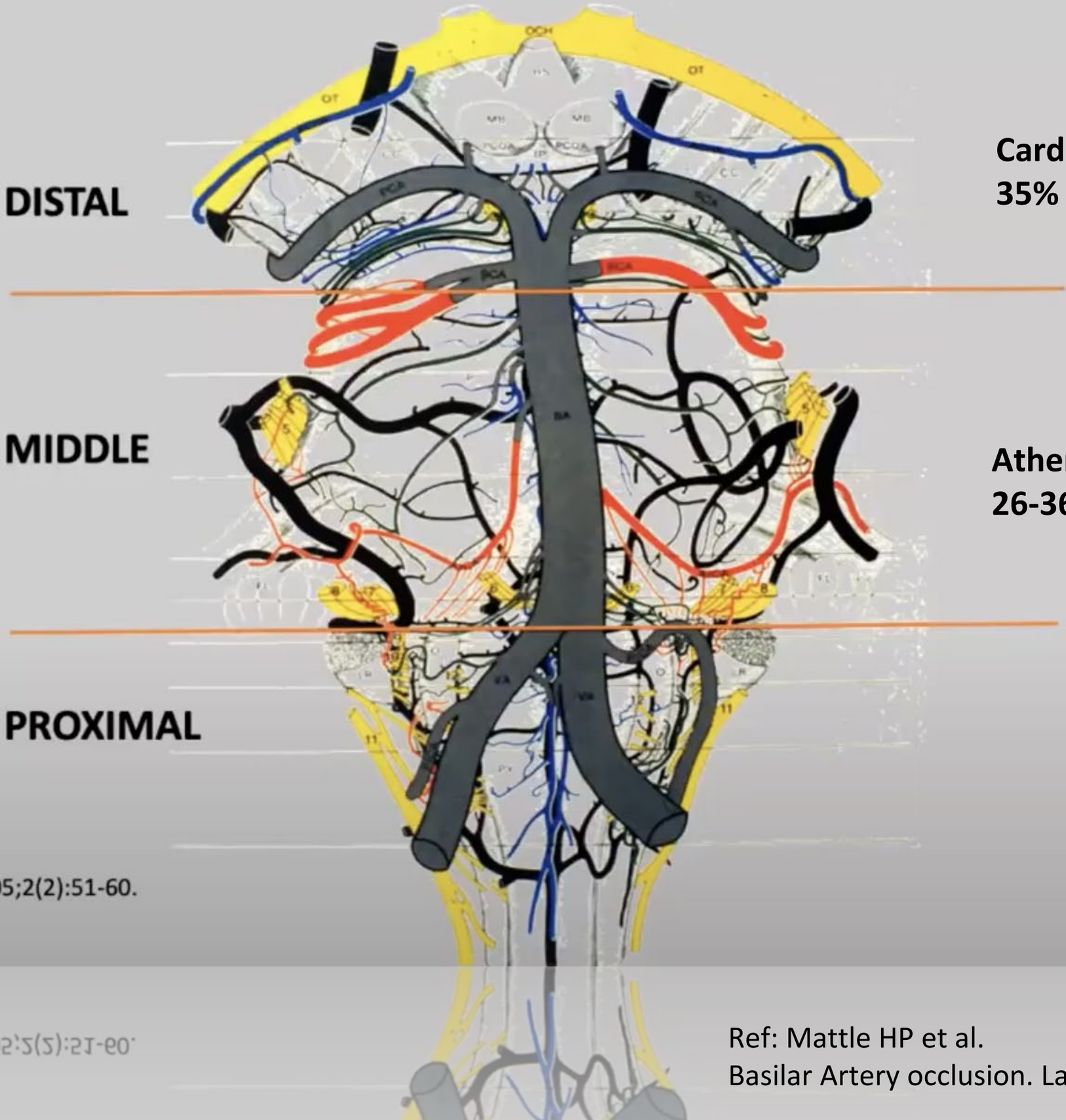
Adapted from
Caplan LR. *Rev Neurol Dis*. 2005;2(2):51-60.

Ref: Mattle HP et al.
Basilar Artery occlusion. Lancet Neuro 2011

DISTAL

MIDDLE

PROXIMAL



Cardioembolic 35%

Atherosclerosis 26-36%

Adapted from
Caplan LR. *Rev Neurol Dis*. 2005;2(2):51-60.

Ref: Mattle HP et al.
Basilar Artery occlusion. Lancet Neuro 2011

Anatomical-clinical correlations in BAO

Occlusions of the **proximal or middle segments** of the basilar artery usually result in large pontine strokes with either hemiplegia or (most usually) quadriplegia. Other effects include reduced consciousness, bilateral extensor plantar sign, dysarthria and dysphagia, horizontal gaze paresis, and other cranial nerve palsies.

The disorder known as **top of the basilar syndrome** results mostly from embolic occlusions of the distal basilar artery and is characterised by visual, oculomotor, and behavioural abnormalities, often without substantial motor dysfunction. Somnolence, vivid hallucinations, and dreamlike behaviour can arise. When infarctions at the top of the basilar artery also affect the temporal and occipital lobes on one or both sides, patients will show hemianopia, cortical blindness, aspects of Balint's syndrome, amnestic dysfunction, and agitated behaviour.

A hallmark of **BAO is reduced consciousness.** The area vital to consciousness is the paramedian tegmental grey matter immediately ventral to the fourth ventricle and aqueduct, extending from the posterior hypothalamic reticular formation rostrally to about the lower third of the pontine tegmentum caudally. This area forms the anatomical basis of the **reticular activating system** and is supplied by **penetrating branches originating** from the basilar artery and **thalamo-perforating branches from the posterior communicating and posterior cerebral arteries.**

Anatomical-clinical correlations in BAO

Large pontine strokes resulting from BAO are the most frequent cause of **locked-in syndrome**, a condition that can be mistaken for coma or persistent vegetative state. The lesion in the pontine base causes quadriplegia, bilateral facial plegia, anarthria, and aphagia.

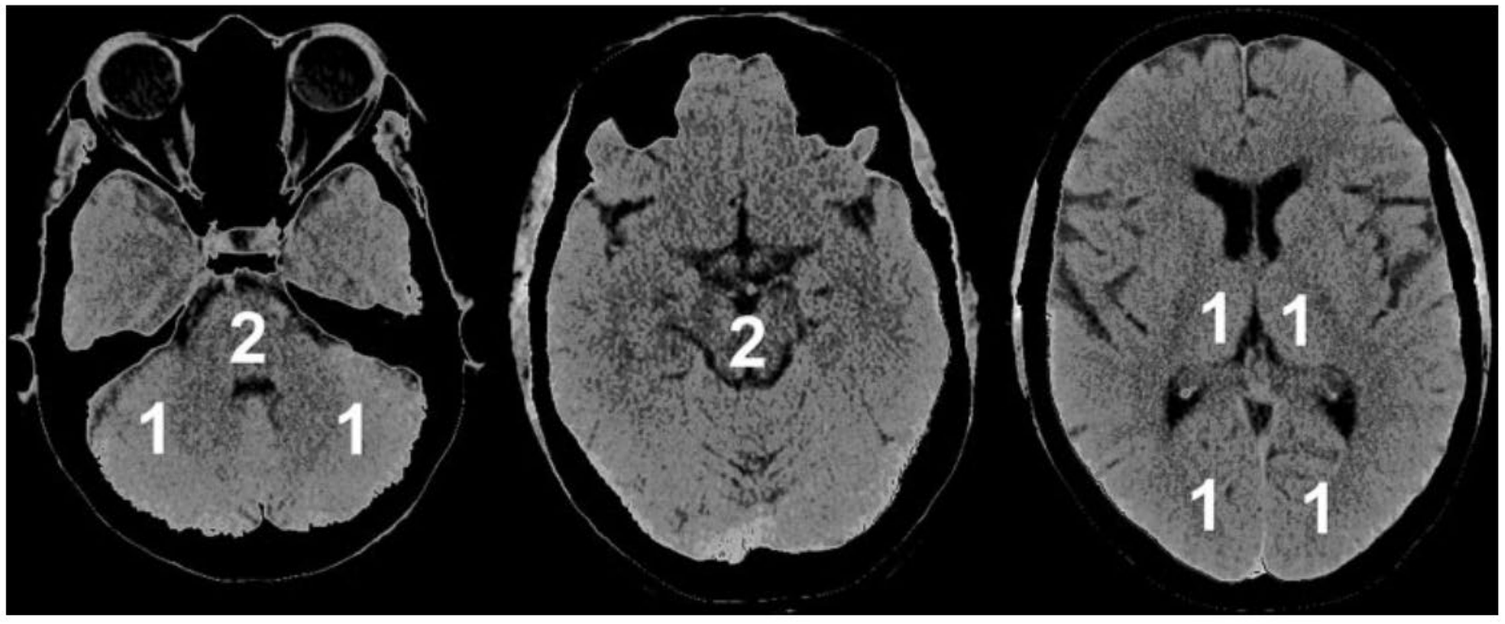
	Anatomical structures
Reduced consciousness or coma	Ascending reticular activating system
Hemiparesis or quadriparesis, hemiplegia or quadriplegia, extensor plantar sign	Corticospinal tracts in pons or cerebral peduncles
Unilateral or bilateral hypaesthesia or anaesthesia	Medial lemnisci and spinothalamic tracts, thalamic nuclei
Ataxia, loss of coordination of limbs and posture, loss of balance	Cerebellum, cerebellar peduncles, proprioceptive tracts
Vertigo, loss of balance, directional nystagmus	Vestibular nuclei, labyrinth, vestibulocerebellum
Headache, neck pain	Trigeminal fibres of vessels and meninges
Horner's syndrome	Sympathetic fibres in dorsal longitudinal fascicle
Disturbance of respiration, heart rate, and blood pressure	Medullary autonomic nuclei and efferent and afferent fibres
Incontinence	Parasympathetic hypothalamic nuclei, sympathetic and parasympathetic connecting fibres from frontal micturition centre to spinal cord
Oculomotor nerve palsy	Fascicle of oculomotor nerve
Nuclear oculomotor nerve palsy, vertical gaze paresis, bilateral ptosis, anisocoria, non-reactive pupils, vertical oculocephalic reflex loss	Oculomotor nerve nucleus, rostral interstitial nucleus of the medial longitudinal fascicle, dorsal commissure
Internuclear ophthalmoplegia	Medial longitudinal fascicle
Horizontal gaze paresis, horizontal oculocephalic reflex loss	Abducens nerve nucleus, paramedian pontine reticular formation
Gaze-evoked nystagmus	Cerebellum and its connections to brainstem
Double vision, strabismus, skew deviation	Brainstem oculomotor system, eye nerves
Facial palsy	Corticobulbar tract, facial nerve nuclei
Tinnitus, hearing loss	Inner ear, cochlear nuclei, lateral lemnisci
Dysarthria, dysphagia, anarthria, aphagia	Corticobulbar tracts, cerebellum, caudal cranial nerve nuclei
Hemianopia, blindness	Occipital lobes
Disorientation, confusion, memory disturbance	Thalamic nuclei, medial temporal lobes
Extension rigidity, jerking, shaking episodes, convulsive-like seizures	Pyramidal tracts

Table 2: **Symptoms and signs of basilar artery occlusion and anatomical structures that are involved**

Transient hypoperfusion caused by a severe focal stenosis can cause transient loss of consciousness without other localising deficits.

Extent of Hypoattenuation on CT Angiography Source Images Predicts Functional Outcome in Patients With Basilar Artery Occlusion

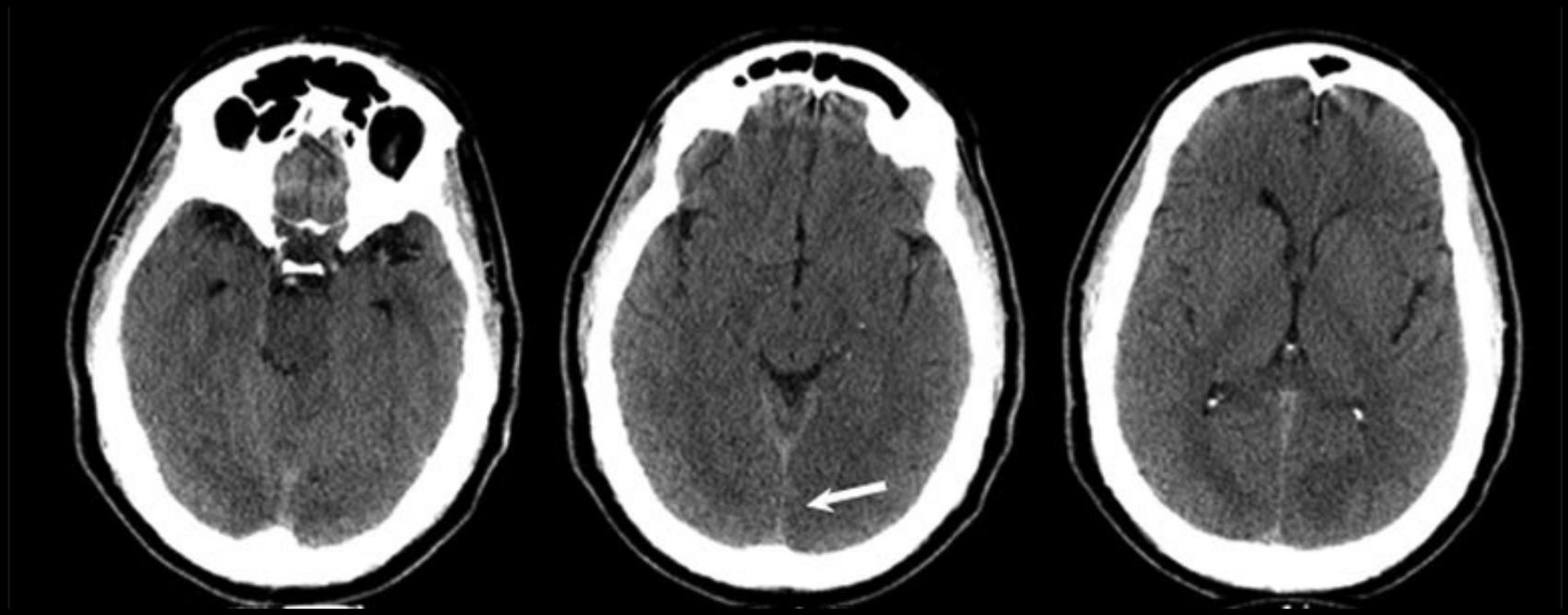
Volker Puetz, MD; P.N. Sylaja, MD; Shelagh B. Coutts, MD; Michael D. Hill, MD, MSc; Imanuel Dzialowski, MD; Pia Mueller, MD; Ulf Becker, MD; Gabriele Urban; Christine O'Reilly, BSc; Philip A. Barber, MD; Pranshu Sharma, MD; Mayank Goyal, MD; Georg Gahn, MD; Ruediger von Kummer, MD; Andrew M. Demchuk, MD



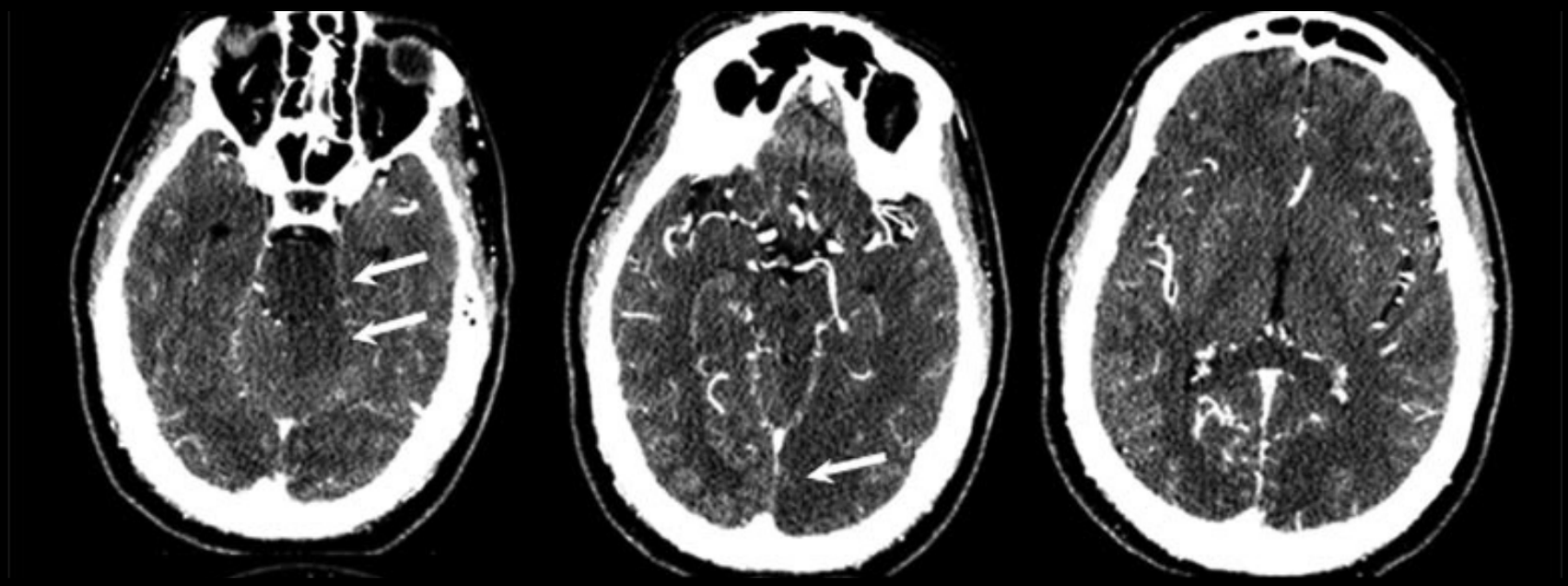
Thalamus (2)
Cerebellum (2)
PCA (2)
Midbrain (2)
Pons (2)

Figure 1. The posterior circulation Acute Stroke Prognosis Early CT score (pc-ASPECTS). From 10 points, 1 or 2 points each (as indicated) are subtracted for early ischemic changes (NCCT) or hypoattenuation (CTASI) in: left or right thalamus, cerebellum or PCA-territory, respectively (1 point); any part of midbrain or pons (2 points). Pc-ASPECTS=10 indicates a normal scan, pc-ASPECTS=0 indicates early ischemic changes (NCCT) or hypoattenuation (CTASI) in all above territories.

PC-ASPECTS on CTA (but not NCCT) may identify BAO patients unlikely to have a favourable outcome despite recanalization

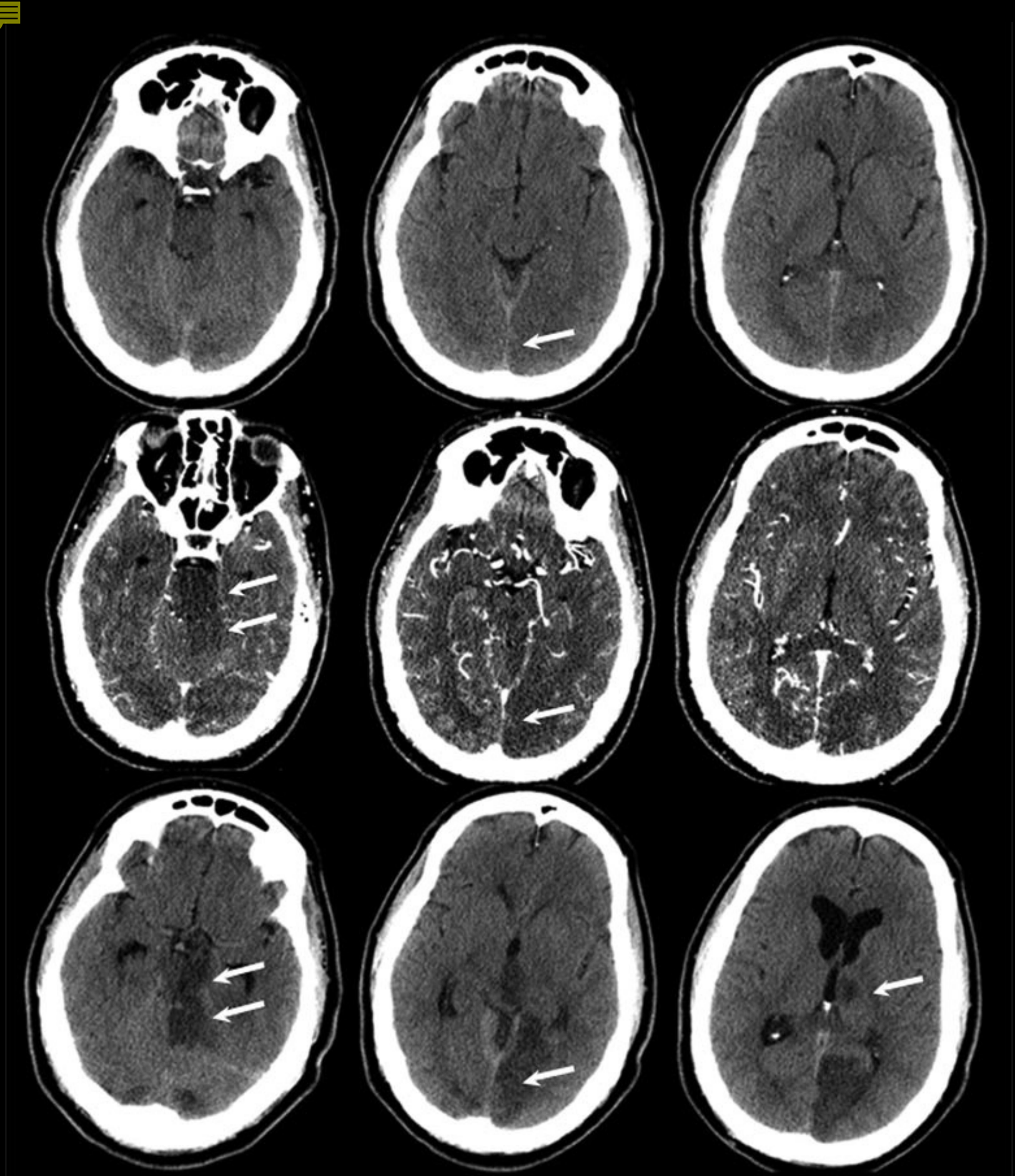


NCCT: pc-ASPECTS 9



CTA: pc-ASPECTS 6

Puetz et al.
Stroke 2008; 39:2485-2490



NCCT: pc-ASPECTS 9

CTA: pc-ASPECTS 7

Follow-up NCCT:
pc-ASPECTS 5

Puetz et al.
Stroke 2008; 39:2485-2490

Extent of Hypoattenuation on CT Angiography Source Images in Basilar Artery Occlusion

Prognostic Value in the Basilar Artery International Cooperation Study

Volker Puetz, MD; Andrei Khomenko, MD; Michael D. Hill, MD; Imanuel Dzialowski, MD; Patrik Michel, MD; Christian Weimar, MD; Christine A.C. Wijman, MD; Heinrich P. Mattle, MD; Stefan T. Engelter, MD; Keith W. Muir, MD; Thomas Pfefferkorn, MD; David Tanne, MD; Kristina Szabo, MD; L. Jaap Kappelle, MD; Ale Algra, MD; Ruediger von Kummer, MD; Andrew M. Demchuk, MD; Wouter J. Schonewille, MD; on behalf of the Basilar Artery International Cooperation Study (BASICS) Group

pc-ASPECTS on CT angiography source images independently predicted death and functional independence at 1 month in the CT angiography subgroup of patients in the BASICS registry

(Stroke. 2011;423454-3459.)

Endovascular treatment versus standard medical treatment for vertebrobasilar artery occlusion (BEST): an open-label, randomised controlled trial

Xinfeng Liu, Qiliang Dai, Ruidong Ye, Wenjie Zi, Yuxiu Liu, Huaiming Wang, Wusheng Zhu, Minmin Ma, Qin Yin, Min Li, Xinying Fan, Wen Sun, Yunfei Han, Qiushi Lv, Rui Liu, Dong Yang, Zhonghua Shi, Dequan Zheng, Xiaorong Deng, Yue Wan, Zhen Wang, Yu Geng, Xingyu Chen, Zhiming Zhou, Geng Liao, Ping Jin, Yumin Liu, Xintong Liu, Meng Zhang, Feng Zhou, Hongchao Shi, Yunfeng Zhang, Fuqiang Guo, Congguo Yin, Guozhong Niu, Mei Zhang, Xueli Cai, Qiyi Zhu, Zhonglun Chen, Yingchun Liang, Bing Li, Min Lin, Wei Wang, Haowen Xu, Xinmin Fu, Wenhua Liu, Xiguang Tian, Zili Gong, Haicun Shi, Chuanming Wang, Penghua Lv, Zhonghai Tao, Liangfu Zhu, Shiquan Yang, Wei Hu, Pingzhou Jiang, David S Liebeskind, Vitor M Pereira, Thomas Leung, Bernard Yan, Stephen Davis, Gelin Xu, Raul G Nogueira*, on behalf of the BEST Trial Investigators†*

Summary

Background Previous randomised trials have shown an overwhelming benefit of mechanical thrombectomy for treating patients with stroke caused by large vessel occlusion of the anterior circulation. Whether endovascular treatment is beneficial for vertebrobasilar artery occlusion remains unknown. In this study, we aimed to investigate the safety and efficacy of endovascular treatment of acute strokes due to vertebrobasilar artery occlusion.

Lancet 2020

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Endovascular Therapy for Stroke Due to Basilar-Artery Occlusion

L.C.M. Langezaal, E.J.R.J. van der Hoeven, F.J.A. Mont'Alverne, J.J.F. de Carvalho, F.O. Lima, D.W.J. Dippel, A. van der Lugt, R.T.H. Lo, J. Boiten, G.J. Lycklama à Nijeholt, J. Staals, W.H. van Zwam, P.J. Nederkoorn, C.B.L.M. Majoie, J.C. Gerber, M. Mazighi, M. Piotin, A. Zini, S. Vallone, J. Hofmeijer, S.O. Martins, C.H. Nolte, K. Szabo, F.A. Dias, D.G. Abud, M.J.H. Wermer, M.J.M. Remmers, H. Schneider, C.M. Rueckert, K.F. de Laat, A.J. Yoo, P.-J. van Doormaal, A.C.G.M. van Es, B.J. Emmer, P. Michel, V. Puetz, H.J. Audebert, O.M. Pontes-Neto, J.-A. Vos, L.J. Kappelle, A. Algra, and W.J. Schonewille, for the BASICS Study Group*

NEJM May 20, 2021

	BASICS 	BEST 
Primary outcome, 90d	mRS 0-3	mRS 0-3
Onset to randomization	0-6h	0-8h
Years Trial	2011-2019	2015-2017
Patients enrolled/target sample size	300/300	131/344

	BASICS 	BEST 
NIHSS (median)	22	30 (IQR 18-38)
IV Thrombolysis	78.6% EVT 79.5% medical	32% EVT 27% medical

	BASICS 	**BEST** 
Crossover rate	Overall: 3% (10/300)	Overall: 13% (17/131)
	3/154 (1.9%) in EVT group 7/146 (4.8%) in medical group	3/66 (4.5%) in EVT group 14/65 (21.5%) in medical group

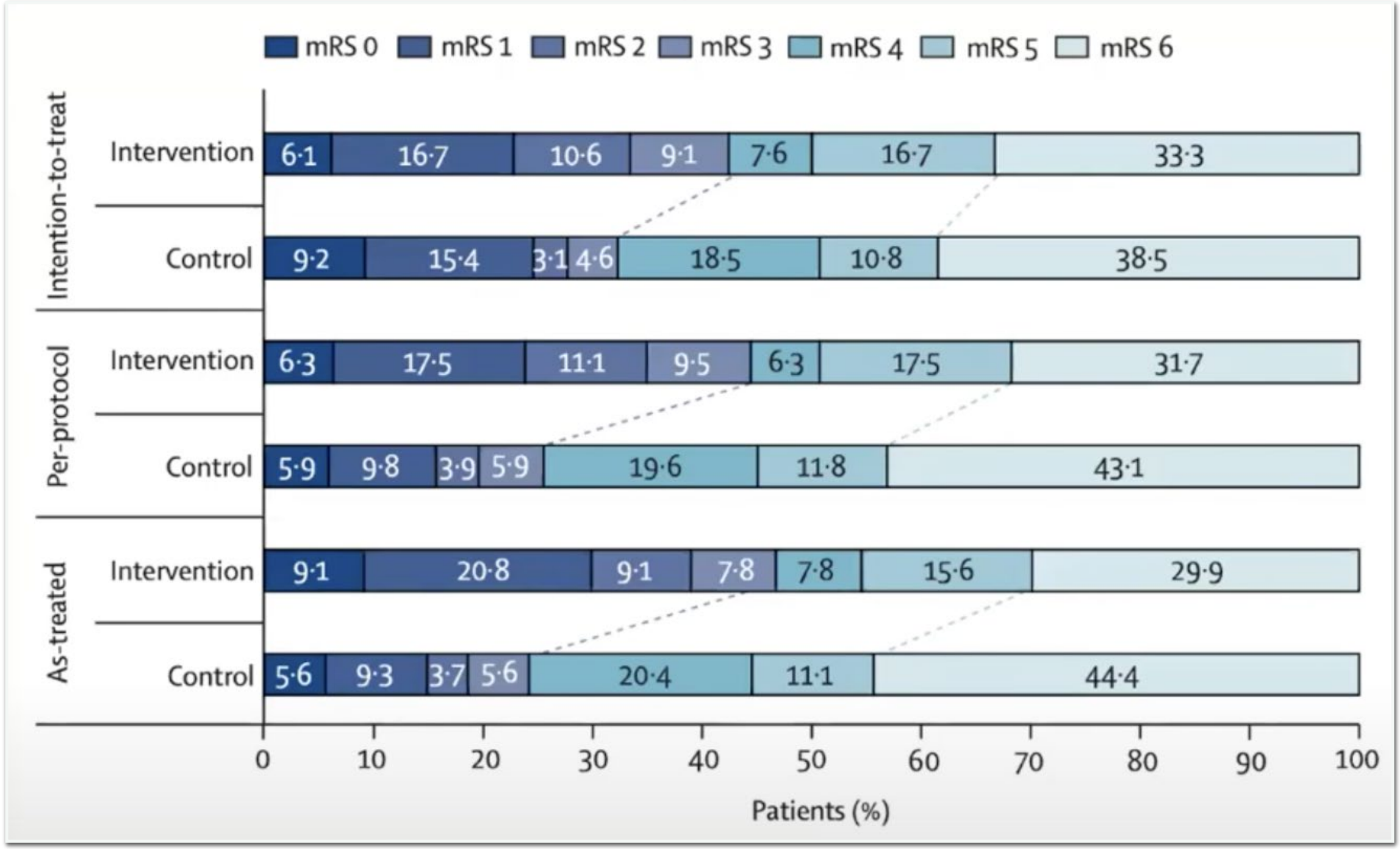
BASICS Primary endpoint

Outcome	Endovascular Therapy (N=154)	Medical Care (N=146)	Risk Ratio, Common Odds Ratio, or Mean Difference (95% CI)†
Primary outcome: favorable functional outcome at day 90: modified Rankin scale score ≤3 — no. (%)‡	68 (44.2)	55 (37.7)	1.18 (0.92 to 1.50)§
Primary safety outcome: overall mortality at day 90 — no. (%)	59 (38.3)	63 (43.2)	0.87 (0.68 to 1.12)§

Safety endpoints

Variable	Endovascular Therapy (N=154)	Medical Care (N=146)
Serious adverse events — no. (%)		
0	82 (53.2)	95 (65.1)
1	48 (31.2)	33 (22.6)
>1	24 (15.6)	18 (12.3)
Symptomatic intracranial hemorrhage ≤3 days after initiation of treatment — no. (%)	7 (4.5)	1 (0.7)

BEST



No difference in favorable outcome (mRS ≤ 3) between the two groups (EVT 28/66 [42%] versus MM 21/65 [32%]; aOR, 1.74 [95% CI, 0.81-3.74])

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Trial of Endovascular Treatment of Acute Basilar-Artery Occlusion

C. Tao, R.G. Nogueira, Y. Zhu, J. Sun, H. Han, G. Yuan, C. Wen, P. Zhou, W. Chen, G. Zeng, Y. Li, Z. Ma, C. Yu, J. Su, Z. Zhou, Z. Chen, G. Liao, Y. Sun, Y. Ren, H. Zhang, J. Chen, X. Yue, G. Xiao, Li Wang, R. Liu, W. Liu, Y. Liu, Li Wang, C. Zhang, T. Liu, J. Song, R. Li, P. Xu, Y. Yin, G. Wang, B. Baxter, A.I. Qureshi, X. Liu, and W. Hu, for the ATTENTION Investigators*

BACKGROUND

Data from trials investigating the effects and risks of endovascular thrombectomy for the treatment of stroke due to basilar-artery occlusion are limited.

METHODS

We conducted a multicenter, prospective, randomized, controlled trial of endovascular thrombectomy for basilar-artery occlusion at 36 centers in China. Patients were assigned, in a 2:1 ratio, within 12 hours after the estimated time of basilar-artery occlusion to receive endovascular thrombectomy or best medical care (control). The primary outcome was good functional status, defined as a score of 0 to 3 on the modified Rankin scale (range, 0 [no symptoms] to 6 [death]), at 90 days. Secondary outcomes included a modified Rankin scale score of 0 to 2, distribution across the modified Rankin scale score categories, and quality of life. Safety outcomes included symptomatic intracranial hemorrhage at 24 to 72 hours, 90-day mortality, and procedural complications.

Methods- ATTENTION

Inclusion criteria:

- 18 years of age or older
- moderate-to-severe acute ischemic stroke consistent with basilar-artery occlusion. A moderate-to-severe acute ischemic stroke was defined by a score of 10 or higher on the National Institutes of Health Stroke Scale (NIHSS; range, 0 to 42, with higher scores indicating greater neurologic deficits) at the time of neuroimaging.
- Basilar-artery occlusion was confirmed on computed tomographic (CT) angiography (CTA), magnetic resonance angiography (MRA), or digital subtraction angiography within 12 hours after the estimated time of stroke onset.

Exclusion criteria:

Patients were excluded if they had pre-stroke score, assessed retrospectively, of at least 3 on the modified Rankin scale among those younger than 80 years of age or a modified Rankin scale score of at least 1 among those 80 years of age or older;

if they had intracranial hemorrhage on neuroimaging;

or if they had a posterior circulation Alberta Stroke Program Early Computed Tomography Score (PC-ASPECTS) of less than 6 points among patients younger than 80 years of age and of less than 8 points among those 80 years of age or older.

Table 1. Characteristics of the Patients at Baseline.*

Characteristic	Thrombectomy (N = 226)	Control (N = 114)
Age — yr	66.0±11.1	67.3±10.2
Male sex — no. (%)	149 (66)	82 (72)
Modified Rankin scale score of 1 or 2 before stroke onset — no. (%)†	25 (11)	14 (12)
Median NIHSS score (IQR)‡	24 (15–35)	24 (14–35)
Median PC-ASPECTS (IQR)§	9 (8–10)	10 (8–10)
Cause of stroke — no. (%)¶		
Large-artery atherosclerosis	108 (48)	42 (37)
Intracranial	90 (40)	33 (29)
Extracranial	18 (8)	9 (8)
Cardioembolism	46 (20)	26 (23)
Undetermined cause	69 (31)	46 (40)
Other determined cause	3 (1)	0
Basilar-artery occlusion site — no./total no. (%)‖		
Vertebral artery V4	20/225 (9)	6/114 (5)
Proximal basilar artery	69/225 (31)	39/114 (34)
Middle basilar artery	62/225 (28)	29/114 (25)
Distal basilar artery	74/225 (33)	40/114 (35)
Intravenous thrombolysis — no. (%)**	69 (31)	39 (34)
Alteplase	60 (27)	35 (31)
Urokinase	9 (4)	4 (4)
Median duration (IQR) — hr††		
From stroke onset to randomization	5.1 (3.6–7.2)	4.9 (3.5–7.0)
From stroke onset to groin puncture	5.6 (3.5–7.5)	NA
From stroke onset to revascularization	6.9 (5.0–8.8)	NA
From groin puncture to revascularization	1.2 (0.8–1.8)	NA
Final modified TICI score of 2b or 3 — no./total no. (%)‡‡	208/223 (93)	NA

Table 2. Outcomes According to Assigned Treatment Group.*

Outcome	Thrombectomy (N = 226)	Control (N =114)	Measure of Effect	Adjusted Value of Effect (95% CI)†
Primary outcome				
Modified Rankin scale score of 0–3 at 90 days — no. (%)	104 (46)	26 (23)	Rate ratio	2.06 (1.46 to 2.91)
Secondary clinical outcomes				
Median distribution across the modified Rankin scale categories (IQR)	4 (2 to 6)	6 (4 to 6)	Common odds ratio	2.87 (1.84 to 4.47)
Modified Rankin scale score of 0 to 2 at 90 days — no. (%)	75 (33)	12 (11)	Rate ratio	3.17 (1.84 to 5.46)
Median NIHSS score (IQR)‡				
At 24–72 hr	21 (7 to 35)	30 (15 to 38)	Beta coefficient	–5.94 (–8.71 to –3.18)
At 5–7 days or discharge	16 (4 to 36)	35 (11 to 41)	Beta coefficient	–8.64 (–12.01 to –5.27)
Barthel Index of 95 or 100 at 90 days — no. (%)§	77 (34)	15 (13)	Rate ratio	2.60 (1.60 to 4.21)
Median EQ-5D-5L score at 90 days (IQR)¶	0.12 (0 to 0.89)	0 (0 to 0.12)	Beta coefficient	0.25 (0.15 to 0.34)
Secondary imaging outcomes				
Patency at 24–72 hr on CTA or MRA — no./total no. (%)‖	147/161 (91)	26/69 (38)	Rate ratio	2.58 (1.89 to 3.51)
Intracranial hemorrhage at 24–72 hr as assessed radiologically — no. (%)	31 (14)	2 (2)	Risk ratio	8.13 (1.98 to 33.4)
Safety outcomes				
Death within 90 days — no. (%)	83 (37)	63 (55)	Risk ratio	0.66 (0.52 to 0.82)
Death within 7 days — no. (%)	57 (25)	38 (33)	Risk ratio	0.75 (0.54 to 1.04)
Symptomatic intracranial hemorrhage according to SITS-MOST criteria at 24–72 hr — no. (%)**	12 (5)	0	—	NE

Subgroup	No. of Patients	Adjusted Rate Ratio (95% CI)
All patients	340	2.06 (1.46–2.91)
Sex		
Male	231	2.13 (1.39–3.26)
Female	109	1.70 (0.98–2.94)
Age		
<70 yr	201	2.01 (1.32–3.04)
≥70 yr	139	2.08 (1.13–3.81)
<80 yr	303	2.09 (1.48–2.95)
≥80 yr	37	2.45 (0.60–9.99)
NIHSS score		
10–19	133	1.51 (1.05–2.18)
≥20	207	3.53 (1.71–7.29)
Estimated time from basilar-artery occlusion to randomization		
<6 hr	216	1.94 (1.26–2.98)
≥6 hr	124	2.21 (1.24–3.97)
Intravenous thrombolysis		
No	232	2.56 (1.56–4.18)
Yes	108	1.57 (0.97–2.54)
Location of basilar-artery occlusion		
Proximal	108	3.09 (1.45–6.58)
Middle	91	2.06 (0.92–4.63)
Distal	114	1.33 (0.86–2.03)
Cause of stroke		
Large-artery atherosclerosis	150	1.77 (1.03–3.04)
Cardioembolism	72	1.69 (1.00–2.86)
Undetermined or other cause	118	2.84 (1.48–5.47)
Intracranial atherosclerotic disease as cause of stroke		
Yes	123	1.56 (0.91–2.68)
No	217	2.51 (1.60–3.94)
Baseline PC-ASPECTS		
<8	68	3.86 (0.98–15.24)
≥8	272	1.94 (1.37–2.74)

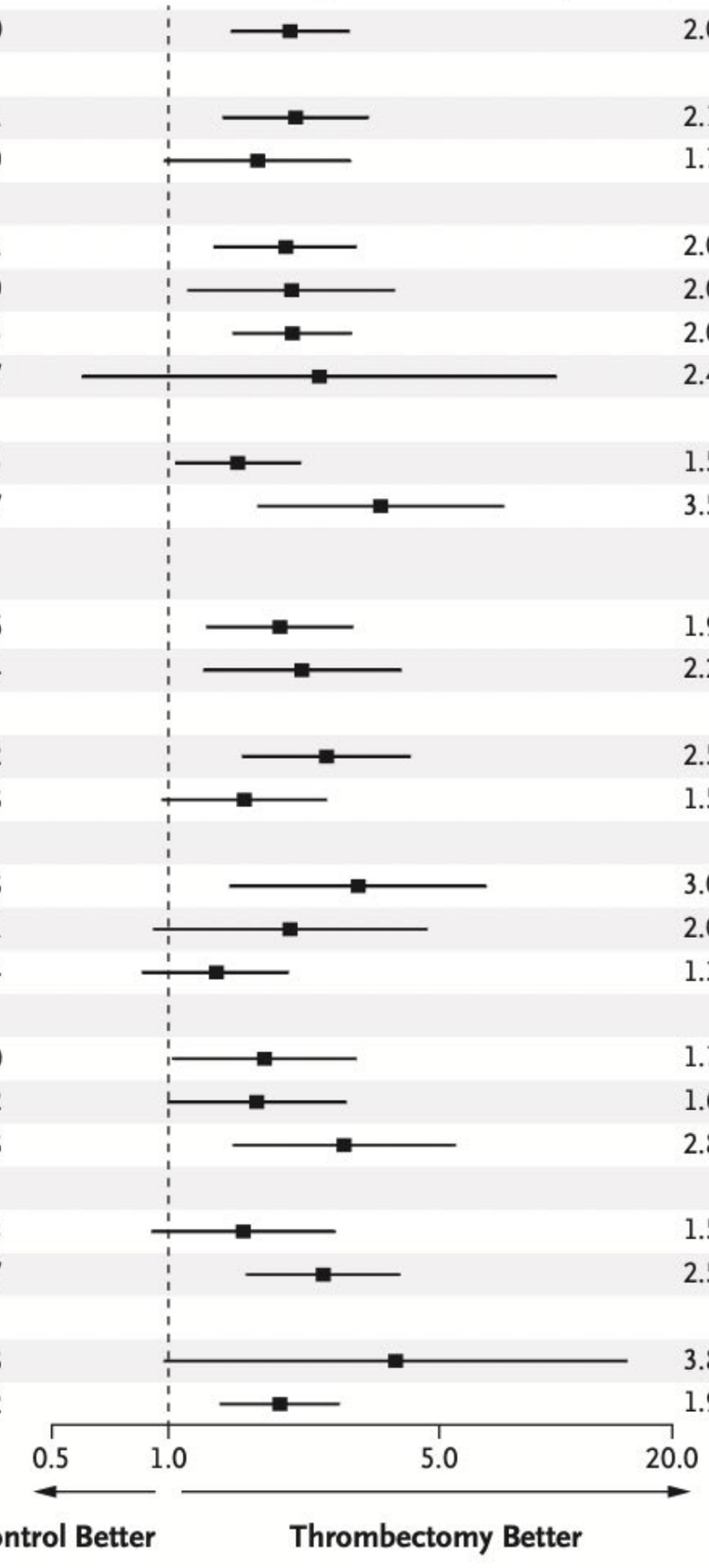


Figure 3. Subgroup Analyses of a Modified Rankin Scale Score of 0 to 3 at 90 Days (Primary Outcome).

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Trial of Thrombectomy 6 to 24 Hours after Stroke Due to Basilar-Artery Occlusion

T.G. Jovin, C. Li, L. Wu, C. Wu, Jian Chen, C. Jiang, Z. Shi, Z. Gao, C. Song, W. Chen, Y. Peng, C. Yao, M. Wei, T. Li, L. Wei, G. Xiao, H. Yang, M. Ren, J. Duan, X. Liu, Qingwu Yang, Y. Liu, Qingfeng Zhu, W. Shi, Qiyi Zhu, X. Li, Z. Guo, Qi Yang, C. Hou, W. Zhao, Q. Ma, Y. Zhang, L. Jiao, H. Zhang, D.S. Liebeskind, H. Liang, A.P. Jadhav, C. Wen, S. Brown, L. Zhu, H. Ye, M. Ribo, M. Chang, H. Song, Jun Chen, and X. Ji, for the BAOCHE Investigators*

BACKGROUND

The effects and risks of endovascular thrombectomy 6 to 24 hours after stroke onset due to basilar-artery occlusion have not been extensively studied.

METHODS

In a trial conducted over a 5-year period in China, we randomly assigned, in a 1:1 ratio, patients with basilar-artery stroke who presented between 6 to 24 hours after symptom onset to receive either medical therapy plus thrombectomy or medical therapy only (control). The original primary outcome, a score of 0 to 4 on the modified Rankin scale (range, 0 to 6, with a score of 0 indicating no disability, 4 moderately severe disability, and 6 death) at 90 days, was changed to a good functional status (a modified Rankin scale score of 0 to 3, with a score of 3 indicating moderate disability). Primary safety outcomes were symptomatic intracranial hemorrhage at 24 hours and 90-day mortality.

Methods-BAOCHE

Inclusion criteria:

- Patients were eligible for inclusion in the trial if they were 18 to 80 years of age;
- had an occlusion of the basilar artery or intracranial segments of both vertebral arteries that could be treated within 6 to 24 hours after symptom onset;
- had a pre- stroke score of 0 or 1 on the modified Rankin scale
- had a score of 10 or higher on the National Institutes of Health Stroke Scale (NIHSS; range, 0 to 42, with higher values indicating more severe deficit) at presentation. Because of slow recruitment, after the enrollment of 61 patients, the inclusion criteria were expanded to allow for the enrollment of patients with an NIHSS score of 6 or higher.

The main exclusion criteria with were

- evidence of recent intracranial hemorrhage;
- the presence of a large infarct in the posterior circulation, defined as a posterior circulation Acute Stroke Prognosis Early CT Score (PC-ASPECTS) of less than 6 on computed tomography (CT), CT angiographic (CTA) source images, or diffusion- weighted magnetic resonance imaging (MRI);
- and the presence on CT, CTA source images, or MRI of a large infarct in the brain stem, defined as a Pons-Midbrain Index of more than 2 points

Results-BAOCHE

- Intravenous alteplase was administered to 18% of the patients overall (14% in the thrombectomy group and 21% n the control group)
- In 32% of the patients, the imaging method used for selection was MRI
- A total of 22 patients arrived at the thrombectomy center within 4.5 hours after stroke onset, 12 (55%) of whom received intravenous thrombolysis, and 39 patients arrived at the referring hospital in less than 4.5 hours from the time of stroke onset, of whom 26 (67%) received intravenous thrombolysis.

Table 1. Characteristics of the Patients at Baseline.*

Characteristic	Thrombectomy (N=110)	Control (N=107)
Age — yr	64.2±9.6	63.7±9.8
Male sex — no. (%)	80 (73)	79 (74)
Medical history		
Atrial fibrillation — no. (%)	14 (13)	13 (12)
Diabetes mellitus — no. (%)	30 (27)	29 (27)
Hypertension — no./total no. (%)	90/110 (82)	79/106 (75)
Modified Rankin scale score of 0 before stroke — no. (%)	85 (77)	89 (83)
NIHSS score†		
Median (IQR)	20 (15–29)	19 (12–30)
Distribution — no. (%)		
6–20	66 (60)	61 (57)
>20	44 (40)	46 (43)
Median systolic blood pressure at hospital arrival (IQR) — mm Hg‡	157 (138–175)	152 (138–166)
Median glucose level at hospital arrival (IQR) — mmol/liter§	8.0 (6.4–9.9)	7.6 (6.0–10.2)
Intravenous thrombolysis — no. (%)	15 (14)	23 (21)
Imaging characteristics		
Median PC-ASPECTS (IQR)¶	8 (7–10)	8 (7–10)
Median Pons-Midbrain Index (IQR)‖	1 (0–2)	1 (0–2)
Basilar-artery occlusion site — no./total no. (%)**		
Proximal basilar artery	53/107 (50)	45/105 (43)
Middle basilar artery	40/107 (37)	37/105 (35)
Distal basilar artery	13/107 (12)	23/105 (22)
Workflow times		
Distribution — no. (%)		
6–12 hr	64 (58)	71 (66)
>12 hr	46 (42)	36 (34)
Median duration (IQR) — min		
From stroke onset to randomization	664 (512–861)	662 (492–838)
From stroke onset to revascularization††	790 (626–1000)	NA
From hospital admission to groin puncture‡‡	153 (99–235)	NA
From groin puncture to revascularization§§	85 (59–129)	NA

Results-BAOCHE

Table 2. Trial Outcomes.*

Outcome	Thrombectomy (N=110)	Control (N=107)	Measure of Effect	Adjusted Value (95% CI)†
Primary outcome				
Modified Rankin scale score of 0–3 at 90 days — no. (%)	51 (46)	26 (24)	Rate ratio	1.81 (1.26 to 2.60)‡
Secondary outcomes				
Modified Rankin scale score at 90 days§	NA	NA	Common odds ratio	2.64 (1.54 to 4.50)
Modified Rankin scale score of 0 to 2 at 90 days — no. (%)	43 (39)	15 (14)	Rate ratio	2.75 (1.65 to 4.56)
Modified Rankin scale score of 0 to 4 at 90 days — no. (%)¶	61 (55)	46 (43)	Rate ratio	1.21 (0.95 to 1.54)
Dramatic neurologic improvement at 24 hr — no./total no. (%)‖	25/101 (25)	9/94 (10)	Rate ratio	2.50 (1.23 to 5.07)
Barthel Index score of 95 to 100 at 90 days — no./total no. (%)**	26/73 (36)	10/56 (18)	Rate ratio	2.20 (1.16 to 4.17)
Basilar-artery patency at 24 hr — no./total no. (%)††	76/83 (92)	15/77 (19)	Rate ratio	4.53 (2.81 to 7.30)
Median EQ-5D-3L score at 90 days (IQR)‡‡	0.78 (0.36–1.00)	0.46 (0.11–0.73)	Mean difference	0.24 (0.10 to 0.39)
Reperfusion on digital subtraction angiography — no./total no. (%)§§	89/101 (88)	NA		
Safety outcomes				
Death within 90 days	34 (31)	45 (42)	Risk ratio	0.75 (0.54 to 1.04)
Symptomatic intracranial hemorrhage¶¶				
According to SITS-MOST criteria	6/102 (6)	1/88 (1)	Risk ratio	5.18 (0.64 to 42.18)
According to ECASS II criteria	9/102 (9)	2/88 (2)	Risk ratio	3.88 (0.86 to 17.49)
Asymptomatic intracranial hemorrhage	8/102 (8)	3/88 (3)	Risk ratio	2.30 (0.63 to 8.41)
Procedure-related complication	12 (11)	NA		—
Vessel dissection	4 (4)	NA		—
Vessel perforation	3 (3)	NA		—
Distal embolization	5 (5)	NA		—
Other serious adverse events				
Pneumonia	51 (46)	50 (47)		—
Malignant brain edema	14 (13)	11 (10)		—
Gastrointestinal hemorrhage	15 (14)	10 (9)		—
Acute renal insufficiency	3 (3)	5 (5)		—
Cardiac ischemia	0	4 (4)		—
Acute heart failure	16 (15)	22 (21)		—
Acute respiratory failure	21 (19)	26 (24)		—

Results-BAOCHE

Subgroup	Control	Thrombectomy	Adjusted Rate Ratio (95% CI)
	no./total no.		
All patients	26/107	51/110	1.81 (1.26–2.60)
Age			
≤70 yr	23/80	42/81	1.70 (1.17–2.48)
>70 yr	3/27	9/29	3.04 (0.93–9.87)
Sex			
Male	22/79	38/80	1.61 (1.09–2.36)
Female	4/28	13/30	2.95 (1.14–7.59)
NIHSS score			
6–20	20/61	41/66	1.80 (1.21–2.67)
>20	6/46	10/44	1.83 (0.73–4.58)
NIHSS score			
6–9	6/11	6/6	NE
10–20	14/50	35/60	2.00 (1.23–3.25)
>20	6/46	10/44	1.83 (0.73–4.58)
Randomization window			
6–12 hr	16/71	29/64	1.89 (1.15–3.09)
>12–24 hr	10/36	22/46	1.71 (1.01–2.90)
Baseline PC-ASPECTS			
9 or 10	13/45	17/38	1.42 (0.86–2.34)
<9	13/62	32/68	2.17 (1.28–3.66)
Location of basilar-artery occlusion			
Proximal	11/45	28/53	1.96 (1.15–3.36)
Middle	8/37	18/40	1.67 (0.87–3.22)
Distal	7/23	3/13	NE

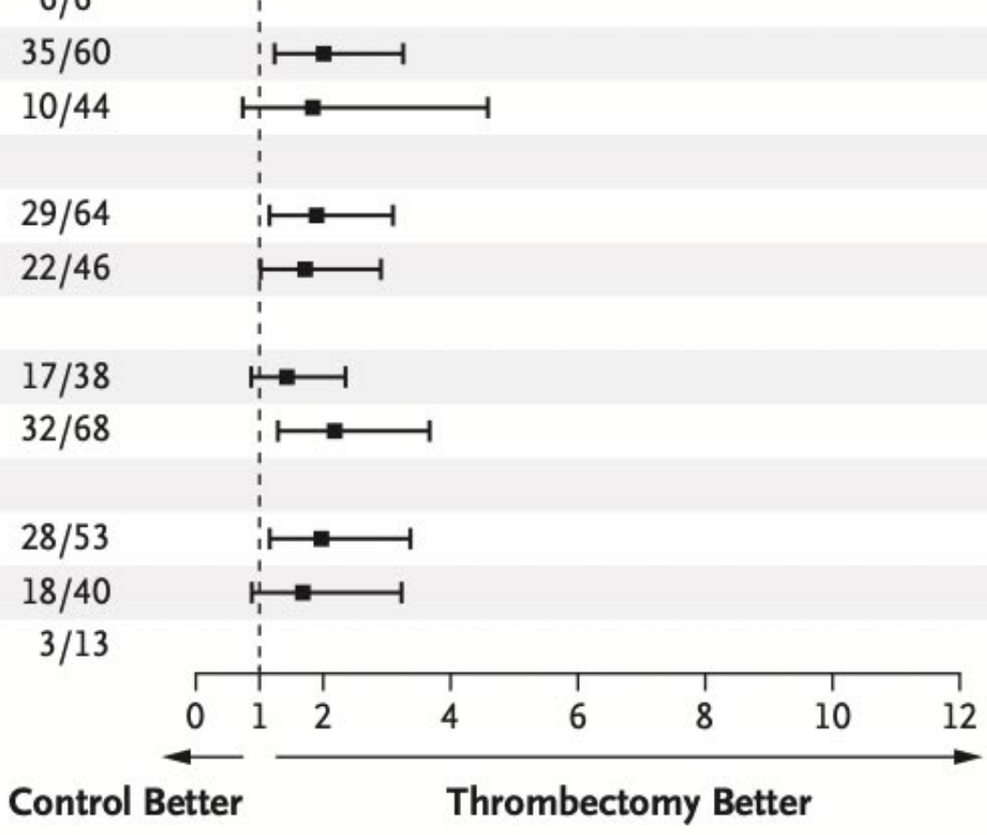


Figure 3. Subgroup Analyses of a Modified Rankin Scale Score of 0 to 3 at 90 Days (Primary Outcome).

Malik *et al. BMC Neurology* (2022) 22:415
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BMC Neurology

RESEARCH Open Access

Mechanical thrombectomy in acute basilar artery stroke: a systematic review and Meta-analysis of randomized controlled trials

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Table 3 Key characteristics

	BASICS	BEST	ATTENTION	BAOCHE
Date	2011–2019	2015–2017	2021–2022	2016–2022
Symptom onset to inclusion (hours)	0–6	0–8	0–12	6–24
Number screened	424	288	507	Data not available
Number of participants	300	131	340	217
Crossover (percentage)	3/154 (1.9) to BMT 7/146 (4.7) to MT	3/66 (4.5) to BMT 14/65 (21.5) to MT	3/226 (1.3) to BMT 3/114 (2.6) to MT	1/110 (0.9) to BMT 4/107 (3.7) to MT
Median NIHSS at presentation (IQR)	Intervention: 21.9 Control: 22.1 (IQR not available)	Intervention: 32 (18–38) Control: 26 (13–37)	Intervention: 24 (15–35) Control: 24 (14–35)	Intervention: 20 (14.5–29) Control: 19 (12–30)
Intravenous thrombolysis (%)	Intervention: 121/154 (78.6) Control: 116/146 (79.5)	Intervention: 18/66 (27) Control: 21/65 (32)	Intervention: 69/226 (30.5) Control: 39/114 (34.2)	Intervention: 15/110 (13.6) Control: 23/107 (21.5)
Blinding	Open-label, blinded outcome assessment	Open-label, blinded outcome assessment	Open-label, blinded outcome assessment	Open-label, blinded outcome assessment
mRS (≤3) (percentage)	Intervention: 68/154 (44.1) Control: 55/146 (37.6)	Intervention: 28/66 (42.4) Control: 21/65 (32.3)	Intervention: 104/226 (46) Control: 26/114 (22.8)	Intervention: 51/110 (46.3) Control: 26/107 (24.2)
Mortality at day 90 (percentage)	Intervention: 59 (38.3) Control: 63 (43.2)	Intervention: 22 (33.3) Control: 25 (38.4)	Intervention: 83 (36.7) Control: 63 (55.2)	Intervention: 34 (30.9) Control: 45 (42.1)
sICH (percentage)	Intervention: 6 (4.5) Control: 1 (0.7)	Intervention: 5 (8) Control: 0	Intervention: 12 (5) Control: 0	Intervention: 6 (8.8) Control: 1 (2.3)
Follow up:	24 hrs, 90 days	24 hrs, 90 days	24 hrs, 90 days	24 hrs, 90 days, 6 months, 1 year

We found a statistically significant benefit in the number of patients treated with MT vs BMT with:

- good functional outcome (mRS 0–3) (RR 1.54, 1.16–2.06, *p* = 0.003)
- functional independence (mRS 0–2) (RR 1.69, 1.05–2.71, *p*=0.03)
- Thrombectomy was associated with a higher level of sICH (RR 7.12, 2.16–23.54, *p*=0.001) but this was not reflected in the mortality rate, in contrast MT was associated with a lower mortality rate (RR 0.76, 0.65–0.89, *p*=0.0004) confirm- ing the benefit of thrombectomy in BAO.

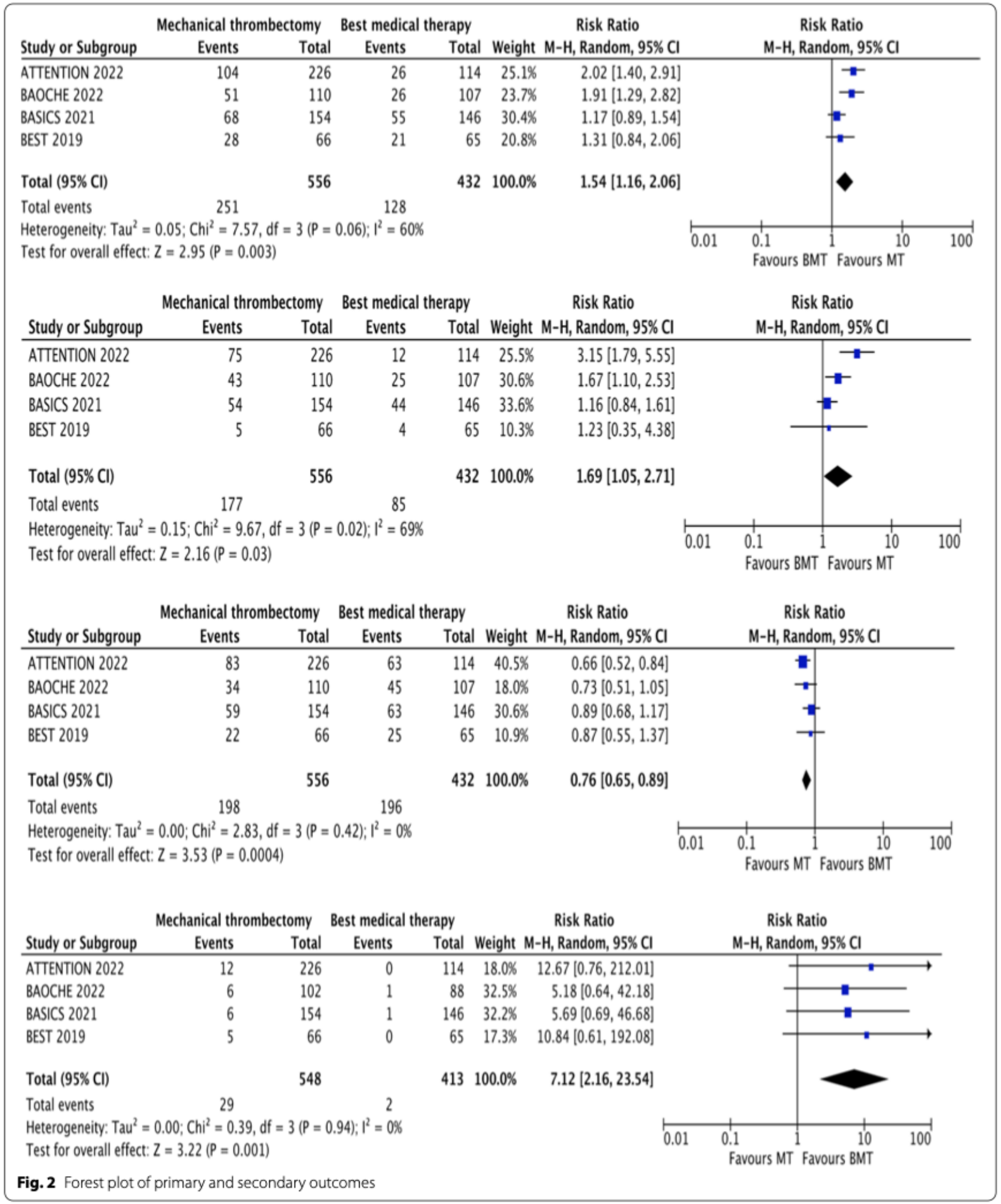
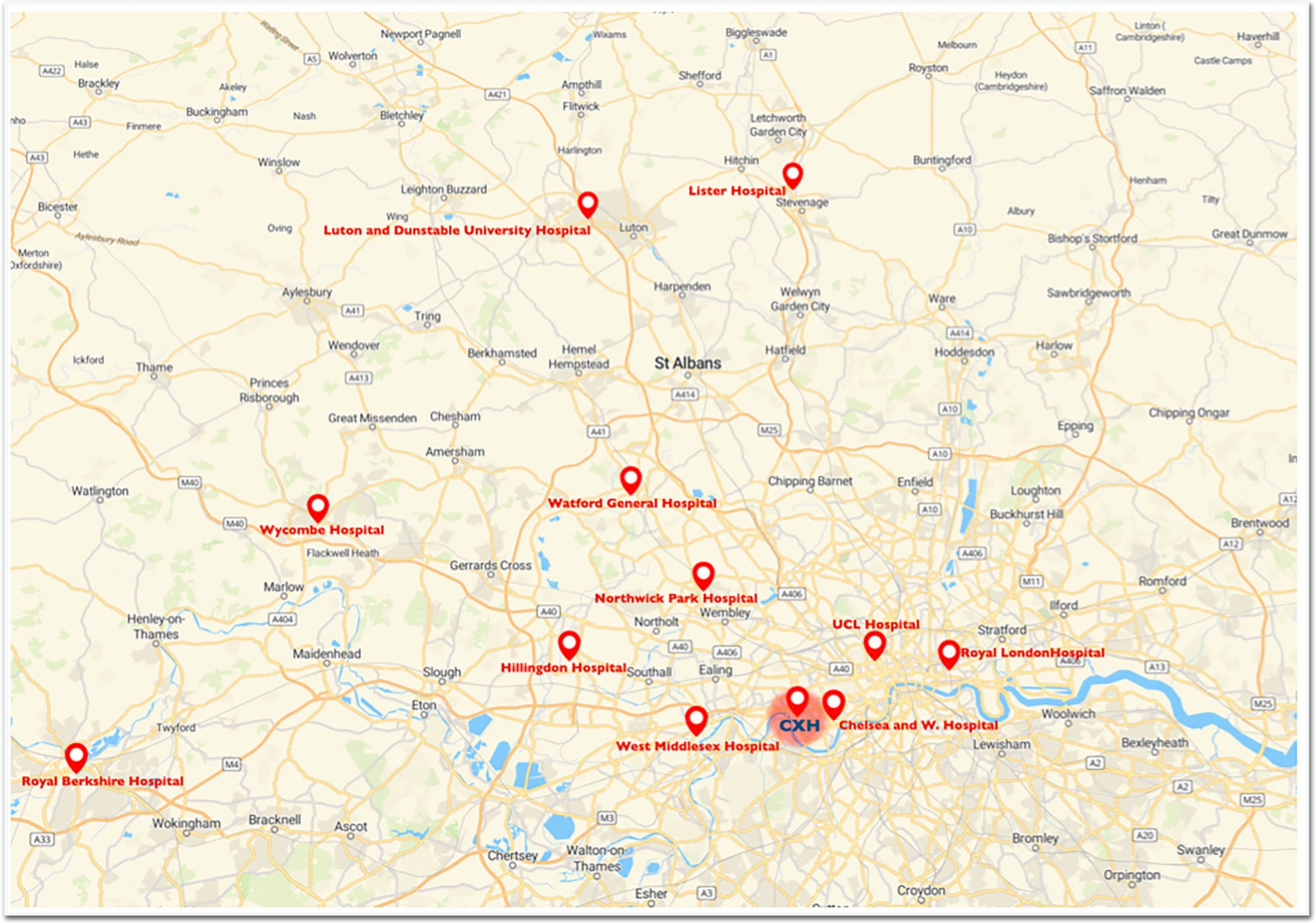


Fig. 2 Forest plot of primary and secondary outcomes

Imperial College London

NHS Imperial College Healthcare NHS Trust

Stroke Department at Charing Cross Hospital.
Regional lead referral stroke center for mechanical thrombectomy for a population of over 6.4 million people



Imperial College London

NHS Imperial College Healthcare NHS Trust

Thrombolysis Call (NCCT + spCTA[1] Arch to CoW)

Stroke Consultant 0900 – 2000
Stroke SpR 2000 – 0900 (0383)

Clinical Criteria:
≥18yo, mRS 0-2
NIHSS ≥6

Proximal Anterior LVO (ICA/M1/M2[2])

Early Windows (0-12hrs)[4]

Radiological Criteria
NCCT ASPECTS ≥5

Late Windows (12-24hrs)

Radiological Criteria
CTP Core <100mL

Basilar Artery Occlusion[3]

Early Windows (0-12hrs)

Radiological Criteria
pc-ASPECTS ≥6

Late Windows (12-24hrs) considered case-by-case with MRI

Imaging Review with Radiology

1700 – 0800 CXH Radiology SpR / INR Fellow (SMH Radiology SpR as last resort 6343)

0800 – 1700
Neurorad SpR (Hot Room)
INR Consultant (Angio Suite)

If accepted

KEY:

Clinical Assessments

Radiological Assessment

Pathway activation

Stroke: Vascular and Interventional Neurology

ORIGINAL RESEARCH

Comparison of Mothership Versus Drip-and-Ship Models for Endovascular Treatment of Basilar Artery Occlusion in the London Metropolitan Area

Lucio D'Anna, PhD; Andrew Falzon, MD; Oi Yean Wong, MD; Jonsdottir Erla, MD; Nikola Christos, MD; Oliver Spooner, MD; Soma Banerjee, MD; Liqun Zhang, MD; Rob Simister, MD

BACKGROUND: To date it is uncertain whether the drip-and-ship (DS) model (transport to the nearest primary stroke centers) or the mothership (MS) model (direct transportation to the comprehensive stroke center) is the best prehospital stroke system of care to deliver endovascular thrombectomy in patients with basilar artery occlusion. In the present analysis, we aim to investigate the impact of MS versus DS model in patients with basilar artery occlusion treated with endovascular thrombectomy in the London metropolitan area.

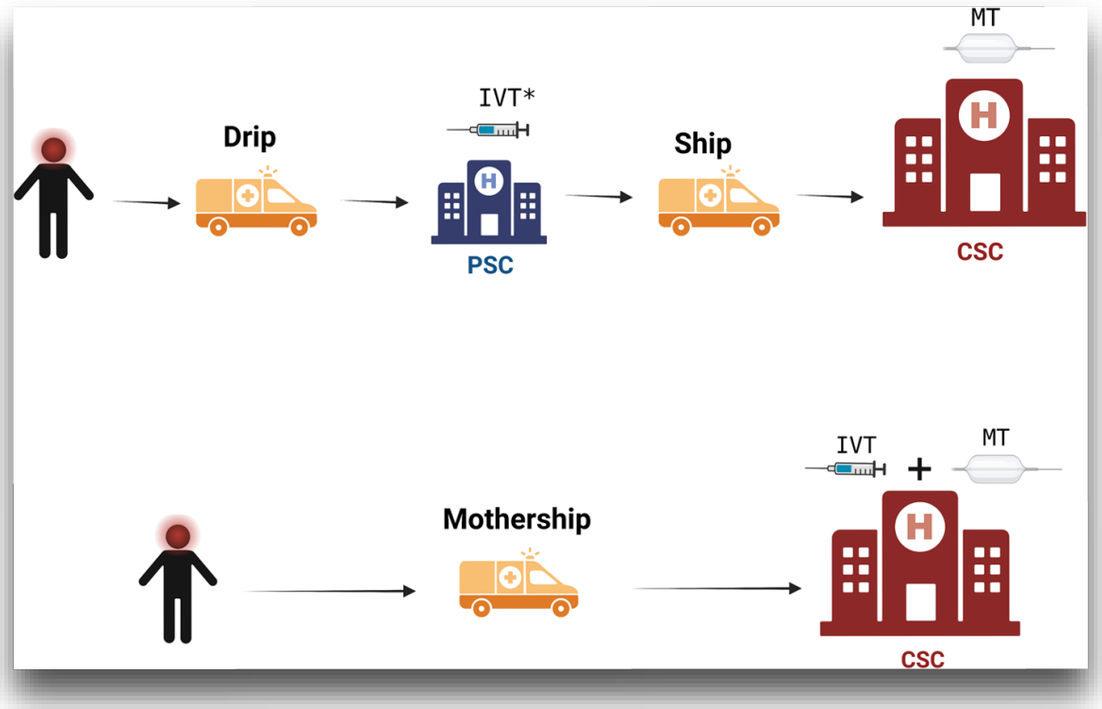
METHODS: This is a multicenter observational, investigator-initiated, retrospective study comparing outcomes (functional independence, defined as modified Rankin scale scores of 0 through 2, the rate of successful reperfusion, and the rate of complications postprocedure) in DS versus MS stroke patients with basilar artery occlusion admitted in 5 thrombectomy capable centers in London (United Kingdom).

Study outcome measures were:

1. functional independence (defined as modified Rankin scale scores of 0 through 2;
2. the rate of successful reperfusion
3. rate of immediate complications postprocedure (death at CSC, parenchymal hematoma, symptomatic hemorrhage, and subarachnoid hemorrhages).

Stroke Vasc Interv Neurol. 2024;0:e001077. DOI: 10.1161/SVIN.123.001077

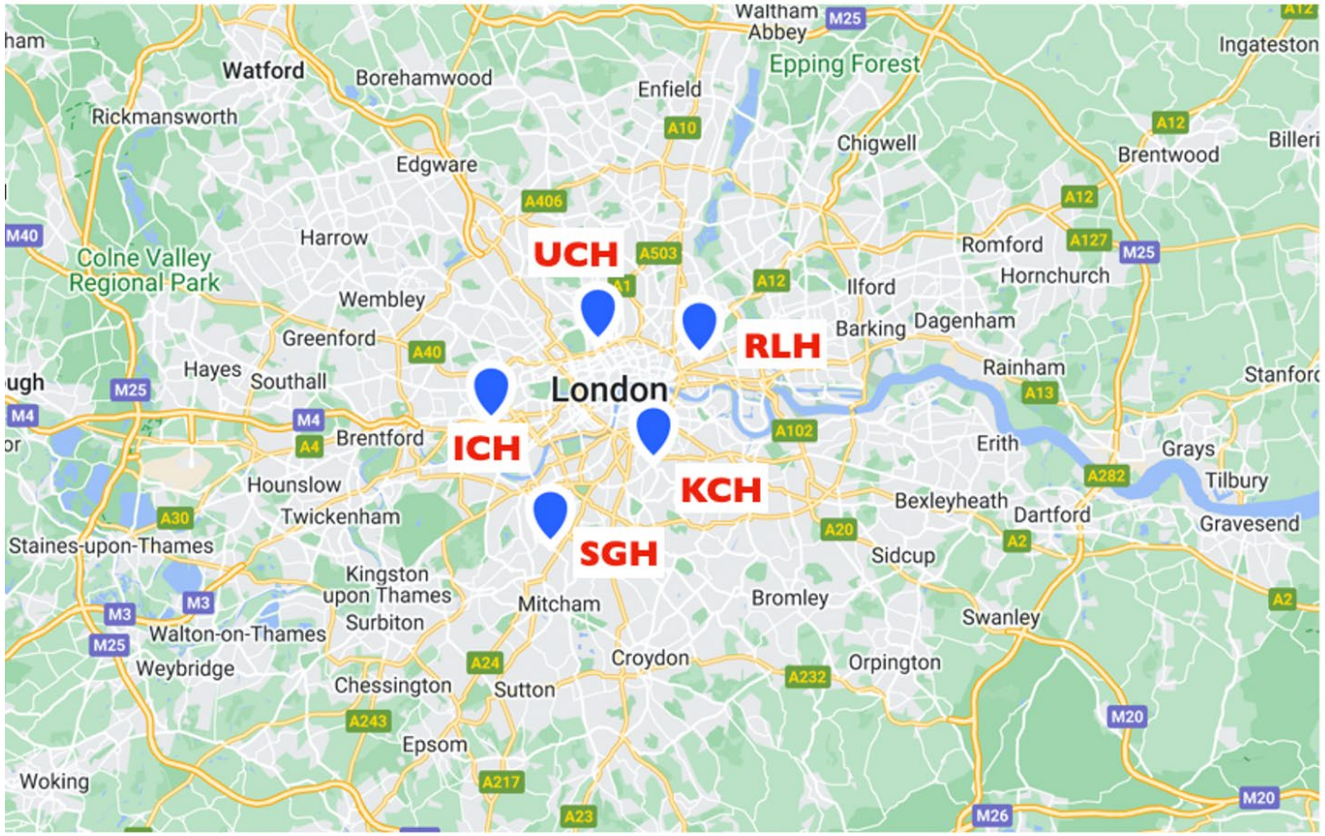
Methods (1)

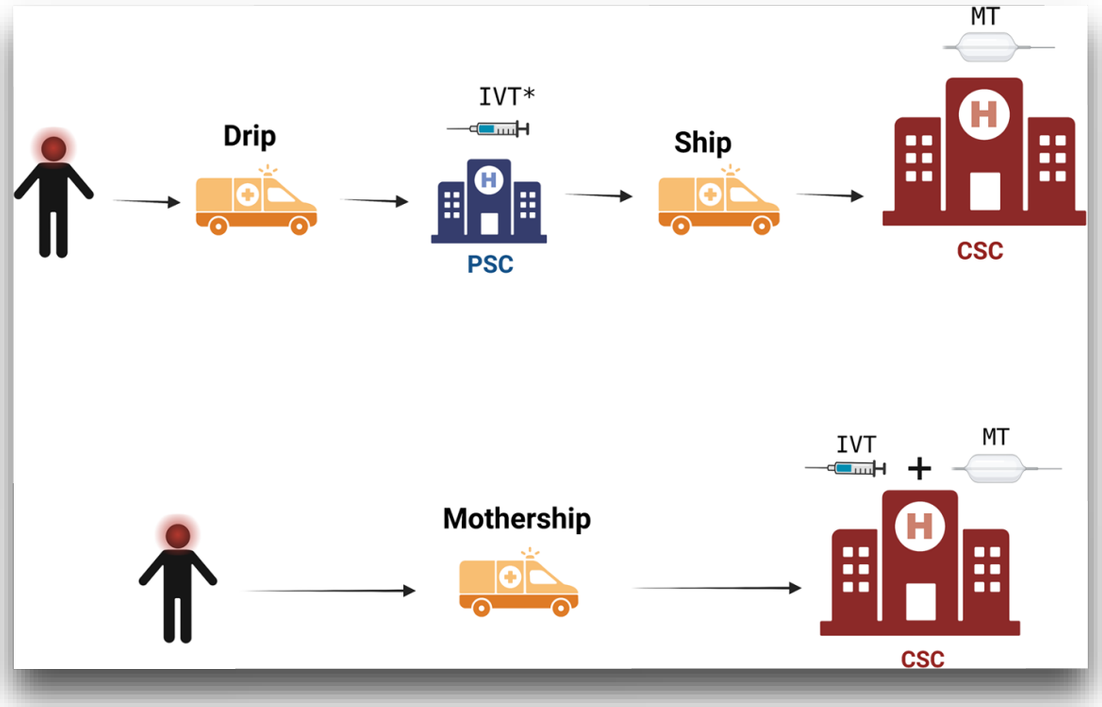


- Observational multi-center study included consecutive patients with acute BAO treated with EVT from 2016 to 2021
- **The London Stroke network** includes 5 MT-capable centres or CSCs able to cover an urban metropolitan area of over 10 million people (Imperial College Healthcare NHS Trust; St George's University of London; University College London; King's College Hospital; Royal London Hospital)
- The CSCs are able to provide both EVT and IVT around the clock every day of the year whereas PSCs can only administer IVT.
- CSCs accept potential candidates 24/7 for EVT that are directly brought to the CSC (MS model) or from the PSCs (DS model) of their stroke networks.

Stroke Vasc Interv Neurol. 2024;0:e001077. DOI: 10.1161/SVIN.123.001077

Methods (2)





1. Patient is initially identified as face, arms, speech, and time positive (FAST protocol) based on the paramedic's initial assessment on the scene.
2. According to the London Stroke network policy, any patient with suspected stroke is transferred to the nearest stroke center that can offer thrombolysis treatment.
3. CSCs can offer both IVT and EVT. Patients at the PSC deemed eligible for EVT are secondarily transferred to a CSC to undergo the procedure. Patients from the PSC were discussed via a telestroke platform with the attending stroke consultant at the CSC.

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Results (1)

Table 1. Patient Demographics, Risk Factors, and Treatments

	Patients (n = 113)	Mothership (n = 38)	Drip-and-ship (n = 75)	*P* value
Demographics				
Age, y [median (IQR)]	63 (53–73)	63 (53.5–73)	64 (53.3–74.5)	0.710
Female sex [n, (%)]	47 (41.6)	16 (42.1)	31 (41.3)	0.940
Cardiovascular risk factors				
Hypertension [n, (%)]	58 (51.3)	19 (50)	39 (52)	0.951
Diabetes [n, (%)]	23 (20.4)	6 (15.8)	17 (22.7)	0.395
Hypercholesterolemia [n, (%)]	32 (28.3)	10 (26.3)	22 (29.3)	0.740
Current smoking or smoked in the past, [n, (%)]	43 (38.1)	22 (57.9)	21 (28)	0.002
Coronary artery disease [n, (%)]	15 (13.3)	5 (15.6)	10 (11.8)	0.985
Congestive heart failure [n, (%)]	9 (7.9)	2 (5.3)	7 (9.3)	0.456
Atrial fibrillation [n, (%)]	20 (17.7)	6 (15.8)	14 (18.7)	0.709
Atrial fibrillation on oral anticoagulant [n, (%)]	13 (11.5)	3 (7.9)	10 (13.3)	0.576
Malignancy [n, (%)]	6 (5.3)	1 (2.6)	5 (6.7)	0.476
Previous stroke/TIA [n, (%)]	14 (12.4)	7 (18.4)	7 (9.3)	0.169
Antiplatelet therapy on admission [n, (%)]	16 (14.2)	4 (10.5)	12 (16.0)	0.954
NIHSS score on admission [median (IQR)]	13 (8.5–23)	13 (8–23)	12.5 (10.75–23.25)	0.654
Baseline mRS score [median (IQR)]	0 (0–1)	0 (0–1)	0 (0–1)	0.248
Use of IVT [n, (%)]	64(56.7)	25(65.8)	39(52.0)	0.165
Onset to needle time for IVT at local hospital (minute) [median (IQR)]	-	145 (56-200)	128 (40–180)	0.180
Onset to groin puncture time (minute) [median (IQR)]	-	260 (89-300)	303(93–393.5)	0.030

IQR indicates interquartile range; IVT, intravenous thrombolysis; mRS, modified Rankin scale; NIHSS, National Institutes of Health Stroke Scale; and TIA, transient ischemic attack.

Results (2)

Table 3. Logistic Regression Analysis for Predictors of mRS Score 0–2 at 90 Days

Characteristics	Univariate regression OR (95% CI)	*P* value	Multivariate regression OR (95% CI)	*P* value
Age per 1 y	0.80 (0.76–0.89)	0.005	0.98 (0.96–0.99)	0.050
Sex (female)	1.91 (0.88–4.12)	0.096		
Hypertension	0.65 (0.30–1.41)	0.281		
Diabetes	0.96 (0.38–2.46)	0.939		
Hypercholesterolemia	0.87 (0.38–2.02)	0.751		
Current smoking or smoked in the past	0.36 (0.16–0.83)	0.017	0.38 (0.27–0.97)	0.768
Coronary artery disease	1.38 (0.46–4.12)	0.562		
Congestive heart failure	2.00 (0.50–7.89)	0.322		
Atrial fibrillation	0.78 (0.28–2.13)	0.627		
Atrial fibrillation on oral anticoagulant	0.87 (0.26–2.87)	0.821		
Malignancy	1.45 (0.27–7.55)	0.659		
Previous stroke/TIA	0.82 (0.26–2.62)	0.737		
Antiplatelet therapy on admission	1.48 (0.49–4.46)	0.486		
NIHSS score on admission per 1 point	0.90 (0.84–0.96)	0.002	0.92 (0.84–0.97)	0.016
Use of IVT	0.72 (0.16–2.62)	0.747		
Mothership model	1.60 (1.09–1.24)	<0.001	1.17 (1.11–1.26)	0.003
Onset to needle time for IVT at local hospital per minute	0.94 (0.32–2.46)	0.839		
Onset to groin puncture time (per every 30 minutes)	1.22 (1.16–1.39)	0.002	1.19 (1.09–1.29)	0.008
Favorable (2b, 2c, 3) postintervention TICI	2.46 (1.48–12.51)	<0.001	1.05 (1.02–1.06)	0.002

IVT indicates intravenous thrombolysis; mRS, modified Rankin scale; NIHSS, National Institutes of Health Stroke Scale; OR, odds ratio; TIA, transient ischemic attack; and TICI, Thrombolysis in Cerebral Infarction.

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Results (3)

Table 4. Logistic Regression Analysis for Composite Outcome of Postoperative Complications

Characteristics	Univariate regression OR (95% CI)	*P* value	Multivariate regression OR (95% CI)	*P* value
Age per 1 y	0.98 (0.96–1.01)	0.388		
Sex (female)	0.84 (0.38–1.97)	0.674		
Hypertension	1.06 (0.48–2.34)	0.885		
Diabetes	0.38 (0.12–1.22)	0.104		
Hypercholesterolemia	1.43 (0.60–3.37)	0.419		
Current smoking or smoked in the past	2.93 (1.29–6.65)	0.010	0.26 (0.10–0.67)	0.005
Coronary artery disease	1.08 (0.34–3.43)	0.895		
Congestive heart failure	1.80 (0.45–7.14)	0.403		
Atrial fibrillation	1.18 (0.43–3.29)	0.739		
Atrial fibrillation on oral anticoagulant	0.43 (0.09–2.07)	0.294		
Malignancy	1.08 (0.12–9.53)	0.940		
Previous stroke/TIA	1.21 (0.38–3.93)	0.741		
Antiplatelet therapy on admission	0.52 (0.06–4.59)	0.559		
NIHSS score on admission per 1 point	0.98 (0.91–1.07)	0.761		
Use of IVT	0.88 (0.81–1.07)	0.741		
Mothership model	0.50 (0.22–1.13)	0.098	0.39 (0.16–0.98)	0.045
Onset to needle time for IVT at local hospital per min	0.87 (0.42–1.46)	0.639		
Onset to groin puncture time (per every 30 min)	0.89 (0.79–0.97)	0.223		
Favorable (2b, 2c, 3) postintervention TICI	0.97 (0.22–4.13)	0.964		

IVT indicates intravenous thrombolysis; NIHSS, National Institutes of Health Stroke Scale; OR, odds ratio; TIA, transient ischemic attack; and TICI, Thrombolysis in Cerebral Infarction.

Take home message

- The long-awaited question of whether to use MT in BAO has now been answered
- MT is associated with lower rates of disability and death in BAO despite an increase risk of sICH and procedural complications
- Further study to assess the best pre-hospital system of care

Thank you for your attention