Stroke: Vascular and Interventional Neurology

ORIGINAL RESEARCH

Aspiration Versus Stent Retriever Thrombectomy in Basilar-Artery Occlusion; Results From the BASICS Trial

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BACKGROUND: Both aspiration and stent retriever thrombectomy are safe and effective in patients with acute ischemic stroke due to large vessel occlusion in the anterior circulation. Little is known on the outcomes of these techniques in patients with basilar artery occlusion. This study aimed to compare clinical, technical, and safety outcomes of aspiration and stent retriever thrombectomy as first-line treatment for basilar artery occlusion in the BASICS (Basilar artery International Cooperation Study) trial.

METHODS: For this post hoc analysis of the BASICS trial, all patients with a basilar artery occlusion who received endovascular treatment with either direct aspiration or stent retriever thrombectomy as first-line approach were included. When both techniques were registered as first choice, patients were considered to have been treated with stent retriever. The primary outcome was favorable functional outcome, defined as a modified Rankin scale score of 0–3 at 90 days follow-up, and analyzed using binary logistic regression analysis. Secondary outcomes included the modified Rankin scale score at 90 days (ranging from 0 to 6), procedure duration, mortality at 90 days, and symptomatic intracranial hemorrhage. Secondary outcomes were analyzed using binary, linear, or ordinal regression analyses. All analyses were adjusted for predefined variables.

RESULTS: Among 158 BASICS patients treated with endovascular treatment,127 were treated with either stent retriever (N=67, 53%), or aspiration (N=60, 47%) as the first-line treatment modality. We observed no significant difference in favorable functional outcome between patients treated with aspiration and stent retriever thrombectomy as first modality (adjusted odds ratio, 1.80; [95% CI, 0.68–4.76]). Also modified Rankin scale score at 90 days (adjusted common odds ratio, 0.62; [95% CI, 0.30–1.27]) and incidence of symptomatic intracranial hemorrhage (adjusted odds ratio, 0.61; [95% CI, 0.08–4.76]) showed no significant differences between both techniques. Procedure time was shorter with a median of 32 versus 47 minutes (26%; 95% CI, −42 to −6) and mortality rates at 90 days were lower (adjusted odds ratio, 0.36; [95% CI: 0.13–1.00]) in the direct aspiration group.

CONCLUSIONS: This study shows no difference in favorable functional outcome in patients with a basilar artery occlusion treated with direct aspiration compared with patients treated with stent retriever thrombectomy within the BASICS trial, despite a shorter procedure time and lower mortality rate at 90 days.

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Basilar artery occlusion (BAO) is a rare condition with high mortality and morbidity rates. BAOs represent about 1% to4% of all ischemic strokes.[1,2] Recent randomized clinical trials have shown that endovascular treatment (EVT) is not only effective in anterior circulation large vessel occlusions but also in BAOs.[3,4]

Aspiration and stent retriever thrombectomy are the most frequently used EVT techniques.[5] In the anterior circulation, equal functional outcomes between stent retriever and direct aspiration thrombectomy – as the method of first choice – have been described.[6,7] However, studies of EVT technique in patients with BAO are scarce. A recent study showed superior clinical and technical outcomes of direct aspiration over stent retriever thrombectomy in patients with a posterior circulation large vessel occlusion, though in a retrospective nonrandomized cohort.[8]

The aim of our retrospective analysis was to compare first-line aspiration to stent retriever thrombectomy in patients with BAO, regarding functional outcomes, reperfusion rates, complications, procedure time, and mortality rates.

Nonstandard Abbreviations and Acronyms

BAO	basilar artery occlusion
BASICS	Basilar artery International Cooperation Study
CTA	computed tomography angiography
EVT	endovascular treatment
mRS	modified Rankin scale

CLINICAL PERSPECTIVE

- Similar clinical outcomes were found in the BASICS (Basilar artery International Cooperation Study) trial between patients with basilar artery occlusion treated with direct aspiration thrombectomy or stent retriever thrombectomy as first choice treatment.
- Shorter procedure times and lower mortality rates at 90 days were seen in patients with a basilar artery occlusion treated with direct aspiration thrombectomy as first-choice treatment.

METHODS

Design and Participants

The data that support the findings of this study are available from the corresponding author upon reasonable request. In this post hoc analysis, we studied patients randomized to the EVT arm of the BASICS (Basilar artery International Cooperation Study) trial.[9] The BASICS study was a multicenter, open-label, international, randomized, controlled trial, which compared EVT versus standard medical care, including intravenous thrombolysis if eligible in patients with a BAO.[10] The primary outcome was favorable functional outcome, defined as a modified Rankin scale (mRS) of 0–3. Patients were randomized between October 23, 2011, and December 6, 2019 and met the following inclusion criteria: age>18 years, a proven BAO on computed tomography (CT)-CT angiography (CTA) or magnetic resonance angiography. EVT had to be feasible within 6 hours after estimated onset of BAO. In the current analysis, we included patients who received EVT with either direct aspiration or stent retriever thrombectomy as first-line approach. Patients were excluded when insufficient information was known regarding endovascular approach or used devices and when occlusion was unreachable.

Outcome Measures

The primary outcome was favorable functional outcome defined as a score of 0–3 on the mRS, ranging from 0 (no disability) to 6 (death), at 90 days follow-up.

Secondary outcomes were the mRS score at 90-day follow-up, reperfusion grade at the end of the endovascular procedure, and procedure time. Safety outcomes were the occurrence of symptomatic intracranial hemorrhages within 3 days after EVT, serious adverse events, and mortality within 90 days after EVT.

Reperfusion grade was evaluated on digital subtraction angiography by a neuroimaging core lab according to the modified Thrombolysis in Cerebral Ischemia score.[11] Modified Thrombolysis in Cerebral Infarction ranges from grade 0 (no reperfusion) to grade 3 (complete reperfusion). Successful reperfusion was defined as modified Thrombolysis in Cerebral Infarction 2B–3. Procedure time was defined as the time between groin puncture and recanalization. An intracranial hemorrhage was considered symptomatic when the patient died or had significant neurological deterioration (an increase of 2 points or more in 1 of the 11 National Institutes of Health Stroke Scale subcategories or an increase of 4 points or more in total in the National Institutes of Health Stroke Scale score), related to the hemorrhage – according to the Heidelberg Bleeding Classification.[12]

Imaging Assessment

Baseline (noncontrast CT and CTA) and follow-up imaging (CTA or magnetic resonance angiography at 24 hours) were assessed by a core laboratory of 6 neuroradiologists. One neuroradiologist scored all the images and one of the others performed a second reading; when no consensus was reached, an independent neuroradiologist was consulted. The location of the thrombus (proximal, middle, or distal in the basilar artery), the length of the thrombus, the posterior circulation Acute Stroke Prognosis Early CT score (a 10-point scale in which points are lost for each of 8 eight regions affected, of which involvement of the midbrain and pons are worth 2 points), and the posterior collateral status (scale from poor collaterals [0] to good collaterals [10]) were scored.[13]

Treatment

Local and national guidelines for treatment of acute ischemic stroke were followed. Stent retriever thrombectomy and direct aspiration are 2 techniques used during EVT. Stent retrievers are placed across the occlusion before expanding and capturing the thrombus. The stent is then carefully retrieved into the guiding catheter. In aspiration thrombectomy, an aspiration catheter is placed proximal to the thrombus, then suction is applied to ingest or withdraw the clot. The choice of technique and devices during EVT was determined by the treating physician. When both techniques were registered as first choice, it was considered as combined and classified as stent retriever technique.

Statistical Analysis

Baseline characteristics were described using descriptive statistics.

Dichotomous and ordinal parameters were tested between groups using Pearson's chi-square test or Fisher's exact test. All continuous parameters were checked for normality using histograms and tested using the independent-samples *t* test, or Mann–Whitney *U* test, depending on distribution.

For the primary outcome, multiple logistic regression analysis was used to compare the effect of direct aspiration and stent retriever thrombectomy on the dichotomized mRS at 90 days. Measures of association were expressed as odds ratio (OR) with corresponding 95% CI. The location and length of the basilar occlusion were checked as potential confounding factors on the primary outcome.

Continuous outcomes were analyzed using multiple linear regression, after checking for normality of distribution of the residuals by using Q–Q plots. The procedure time and the time between BAO and recanalization showed no normality; these outcome data were first transformed using the natural logarithm. The regression coefficient was subsequently exponentiated to receive ratios with stent retriever as first modality. To calculate relative percentages, we used the following formula: (exponentiate(coefficient) − 1) ∗ 100%.

All regressions models were adjusted for age, intravenous thrombolysis before EVT, atrial fibrillation, time from BAO onset to groin puncture, and the posterior circulation Acute Stroke Prognosis Early CT Score on CTA.

Additionally, a sensitivity analysis was performed. After removing patients with the combined first-line approach in the stent retriever thrombectomy group, the analysis was repeated to evaluate the effect of direct aspiration thrombectomy and stent retriever thrombectomy as first-line approach on the primary outcome and mRS at 90 days follow-up. For the subgroup analysis based on the length of the basilar occlusion, the median was used as tipping point. The analyses were performed using RStudio (version 1.3.1093). The level of significance was set at 0.05.

Missing Values

Missing values were imputed using multiple imputation with chained equations. The number of imputations was set to 50. Variables entered in the imputation model were age, sex, baseline National Institutes of Health Stroke Scale score, diabetes mellitus, atrial fibrillation, stroke in patients' history, prestroke mRS, intravenous thrombolysis prior to EVT, baseline posterior circulation Acute Stroke Prognosis Early CT Score on CTA, collateral status, and time from BAO onset to groin puncture. Data after multiple imputation were used only for regression analyses, whereas all descriptive analyses were performed with original data.

The corresponding author had full access to the data and takes responsibility for their integrity and the data analysis. The study was conducted using the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) cohort checklist.

RESULTS

Baseline Characteristics

A total of 158 out of 300 patients received EVT in the BASICS trial, including 7 crossovers from standard medical care to EVT. We excluded 31 patients for further analyses because neither aspiration nor stent retrievers were used (n=3), the first used endovascular approach was unknown (n=7), occlusion site was technically unreachable or was a P1 occlusion (n=6), no persistent occlusion was observed on conventional angiography (n=5), the MERCI device was used and

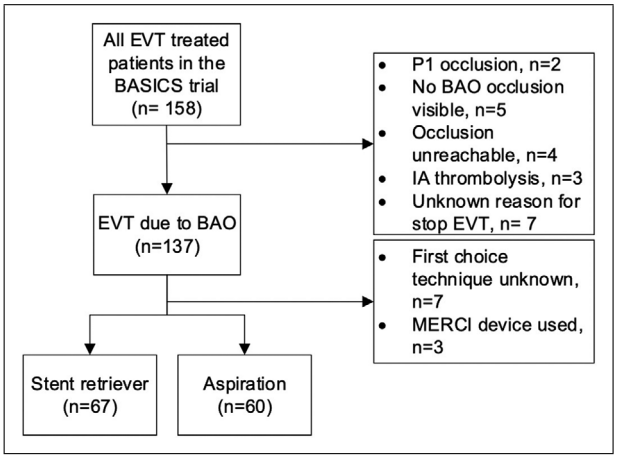

Figure 1. Flow chart of patients through this study. BAO indicates basilar artery occlusion; BASICS, BASilar artery International Cooperation Study; EVT, endovascular treatment; IA, intra-arterial; and MERCI, Mechanical Embolus Removal in Cerebral Ischemia.

not considered as stent retriever (n=3), or the procedure was discontinued for unknown reasons (n=7). Of the remaining 127 patients, 67 patients (53%) received stent retriever thrombectomy as first choice treatment, and 60 (47%) direct aspiration (Figure 1).

The patient characteristics are summarized in Table 1. Only time between estimated time of BAO onset and groin puncture and age were significantly different between stent retriever thrombectomy and direct aspiration groups.

Clinical Outcome

Favorable functional outcome after direct aspiration did not significantly differ from outcome after stent retriever thrombectomy (43% versus 45%; adjusted OR (aOR), 1.80 [95% CI, 0.68–4.76]) (Table 2, Figure 2). A shift toward a 1-point higher mRS score (more disability) with stent retriever thrombectomy as first modality was also not statistically significant (adjusted common OR, 0.62 [95% CI, 0.30–1.27]) (Table 3). The interaction between the length of the basilar occlusion and the EVT was significant for favorable functional outcome (P=0.02). The subgroup analysis suggested that aspiration was more efficient in shorter basilar occlusions and stent retriever thrombectomy in longer basilar occlusions (Table S1).

Technical Outcome

The rate of successful recanalization (modified Thrombolysis in Cerebral Infarction>2B) showed no significant difference between patients treated with direct aspiration (82%) and those treated with stent retriever thrombectomy (71%); aOR, 1.27 (95% CI, 0.43–3.81) (Table 3). Procedure time in the aspiration group (median 32 minutes [25–55]) was significantly shorter than in the stent retriever group (median 47 minutes [32–75]); P=0.02). Regression analysis with transformed data showed similar results, where direct aspiration thrombectomy had 22% (95% CI, −38 to − 2.9), and after adjusting, 26% (95% CI, −42 to − 6.2) shorter procedure time (Table 4).

Safety Outcome

The 90-day mortality rate was 33% in patients treated with direct aspiration as first choice and 39% in the stent retriever group, these differences were significant (aOR, 0.36 [95% CI, 0.36–1.00]). The incidence of symptomatic intracranial hemorrhage was 3% in the direct aspiration group versus 5% in the stent retriever group (aOR, 0.61; [95% CI, 0.08–4.76]). Occurrence of serious adverse events within 90 days after EVT was lower in the aspiration group (40%) compared with the stent retriever group (50%) but not significant (adjusted common OR, 0.57 [95% CI,0.27–1.23]) (Table 3).

Sensitivity Analysis

Fourteen patients were treated with the combined thrombectomy technique as first-line approach. Sensitivity analysis showed that both the favorable functional outcome and the mRS at 90 days follow-up did not differ after removing those 14 patients from the stent retriever group (aOR, 1.26 [95% CI, 0.49–3.22], aOR, 0.63 [95% CI, 0.30–1.35], respectively) (Table S2).

DISCUSSION

This study showed no differences in favorable functional outcomes according to endovascular technique used, despite the shorter procedure time and lower mortality rate at 90 days in patients with BAO, treated with direct aspiration thrombectomy within the BASICS trial.

Clinical and Technical Outcomes

Partly in line with our study, recent studies have shown equal or better outcomes for patients treated with direct aspiration thrombectomy compared with stent retriever thrombectomy in BAO. Shorter procedure times, higher successful recanalization rates, fewer new embolic events, and better favorable functional outcomes were observed.[8,14–16] One study showed that longer procedure times are associated with worse functional outcomes, especially in the posterior circulation.[17] Despite shorter procedure times for patients treated with aspiration we could not show an association with favorable functional outcome. In studies comparing direct aspiration and stent retriever thrombectomy in the anterior circulation, direct aspiration was also associated with shorter procedure times and higher recanalization rates, without differences in favorable functional

Table 1. Baseline Patient Characteristics Treated with Aspiration Versus Stent Retriever Thrombectomy

	Aspiration (n=60)	Stent retriever (n=67)			*P* value
Demographics					
Age (y), mean (SD)	69	(12)	64	(13)	0.04
Male, n (%)	36	(60)	41	(61)	1.00
NIHSS baseline, median [IQR]	24	[10–35]	19	[12–35]	0.83
Prestroke mRS, n/N (%)					0.06
0	47/59	(80)	56/67	(84)	
1	2/59	(3)	7/67	(10)	
2	10/59	(17)	4/67	(6)	
Medical history, n (%)					
Previous posterior stroke	4	(7)	5	(8)	1.00
Atrial fibrillation	18	(30)	18	(27)	0.85
Hypertension	39	(65)	36	(54)	0.27
Diabetes mellitus, n/N (%)	13/60	(22)	10/66	(15)	0.48
Medication, n/N (%)					
Statin	16/59	(27)	22/66	(33)	0.58
Antiplatelet	12/57	(21)	20/67	(30)	0.36
Anticoagulation	10/59	(17)	8/67	(12)	0.58
Stroke characteristics/workflow					
IVT pre-EVT, n (%)	44	(73)	53	(79)	0.58
pc-ASPECTS baseline on CTA, n/N (%)					0.25
0–4	2/56	(3.6)	0/64	(0)	
5–7	10/56	(18)	5/64	(7.8)	
8–10	44/56	(79)	59/64	(92)	
Collaterals on CTA, n/N (%)					0.81
Poor collaterals (<8)	29/55	(53)	36/64	(56)	
Moderate collaterals (8,9)	20/55	(36)	25/64	(39)	
Good collaterals (10)	6/55	(11)	3/64	(4.7)	
Onset to groin (min), mean (SD)*	229	(78)	197	(76)	0.03
Location of the occlusion, n/N (%)					0.85
Proximal	17/56	(30)	21/64	(33)	
Middle	23/56	(41)	23/64	(36)	
Distal	16/56	(29)	20/64	(31)	
Length of occlusion (mm), median [IQR]†	11	[5–21]	11	[7–26]	0.42
Stroke pathogenesis, n/N (%)					0.77
Large artery atherosclerosis	22/56	(39)	26/64	(41)	
Cardioembolism	17/56	(30)	20/64	(31)	
Stroke of undertermined pathogenesis	14/56	(25)	12/64	(19)	
Other determined pathogenesis	3/56	(5.4)	6/64	(9.4)	

CTA indicates CT angiography; EVT, endovascular treatment; IQR, interquartile range; IVT, intravenous thrombolysis; mRS, modified Rankin scale; NIHSS, National Institutes of Health Stroke Scale; and pc-ASPECTS, posterior circulation Alberta Stroke Program Early Computed Tomography score.

*Data were missing in 4 cases in the stent retriever group and in 6 cases in the aspiration group.

†Data were missing for 10 patients in the stent retriever group and for 6 patients in the aspiration group.

outcome.[3,7,18] A possible explanation is because of the multiple factors, which have influence on the functional outcome. Although we adjusted for age, intravenous thrombolysis, atrial fibrillation, time from BAO onset to groin, and posterior circulation Acute Stroke Prognosis Early CT Score, we were never able to adjust for all factors.

Besides EVT technique, another potential predictor for successful treatment is the location of the occlusion.[6] Unlike the anterior circulation, the location of the occlusion in the basilar artery is reported to be associated with recanalization rate: Distal BAO is associated with higher recanalization rates.[19] In our study, the location had no interaction with favorable functional outcome. Remarkably, however, in distal BAO's successful recanalization was observed in all patients of the direct aspiration group, whereas in 11% of the patients in the stent retriever group no successful recanalization

Table 2. Clinical and Functional Outcome According to Treatment as First Choice

	Aspiration, n=60		Stent retriever, n=67		*P* value
Favorable mRS at 90 d, n (%)	26	(43)	30	(45)	1.00
mRS at 90 d, n (%)					0.29
0	3	(5)	4	(6)	
1	4	(7)	11	(16)	
2	12	(20)	9	(13)	
3	7	(12)	6	(9)	
4	7	(12)	2	(3)	
5	7	(12)	9	(13)	
6	20	(33)	26	(39)	
Successful reperfusion (mTICI 2B–3), n/N (%)*	23/28	(82)	35/49	(71)	0.44
Post-EVT mTICI, n/N (%)*					0.38
0	0/28	(0)	3/49	(6.1)	
1	1/28	(3.6)	6/49	(12)	
2A	4/28	(14)	5/49	(10)	
2B	14/28	(50)	17/49	(35)	
3	9/28	(32)	18/49	(37)	
Workflow (minutes), median [IQR]					
Procedure time†	32	[25–55]	47	[32–75]	0.02
Onset BAO to recanalization‡	299	[222–367]	273	[200–326]	0.08
Mortality at 90 d, n (%)	20	(33)	26	(39)	0.65
SAE any, n (%)					0.48
0	36	(60)	33	(49)	
1	16	(27)	23	(34)	
>1	8	(13)	11	(16)	
Symptomatic ICH, n (%)	2	(3)	3	(5)	1.00

BAO indicates basilar artery occlusion; EVT, endovascular treatment; ICH, intracranial hemorrhage; IQR, interquartile range; mRS, modified Rankin scale; mTICI, modified Thrombolysis in Cerebral Infarction; and SAE, serious adverse event.

*The mTICI was scored on digital subtraction angiographies.

†Procedure time was missing in 11 cases in the aspiration group and in 6 cases in the stent retriever group.

‡Time between estimated BAO and recanalization was missing in 9 cases in the aspiration group and in 4 cases in the stent retriever group.

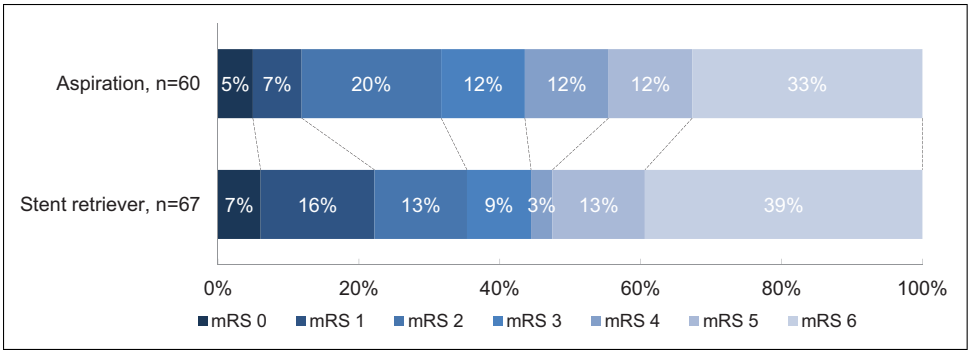

Figure 2. Distribution of the modified Rankin scale between direct aspiration and stent retriever thrombectomy. Multiple logistic regression with adjustment showed no significant difference in favorable functional outcome between both techniques with stent retriever thrombectomy as first modality (adjusted OR, 1.80 [95%CI, 0.68–4.76]). mRS indicates modified Rankin scale; and OR, odds ratio.

was seen (Table S3). The length of the basilar occlusion had an interaction with EVT for functional outcome, in which direct aspiration was potentially more beneficial in shorter BAOs and stent retriever thrombectomy in longer occlusions. This may be explained by the fact that direct aspiration is more likely to cause distal fragmentation when the occlusion is long.

Safety Outcomes

Both in the anterior and the posterior circulation, no differences in mortality at 90 days between the 2 techniques were described in recent studies.[20–22] We observed lower mortality rates for direct aspiration, after adjusting. This result may play a role in decision for EVT technique. In addition, for the occurrence of

Table 3. Regression Analyses Outcomes on Clinical, Technical, and Safety Outcomes

Stent retriever thrombectomy as first modality	EE	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Favorable mRS at 90 d	OR	0.94 (0.46–1.92)	1.80 (0.68–4.76)
mRS at 90 d	cOR	1.02 (0.54–1.90)	0.62 (0.30–1.27)
Successful reperfusion (mTICI 2B–3)	OR	1.19 (0.45–3.15)	1.27 (0.43–3.81)
Post-EVT mTICI	cOR	1.04 (0.49–2.22)	1.04 (0.46–2.39)
Mortality at 90 d	OR	0.79 (0.38–1.64)	0.36 (0.13–1.00*)
SAE any	OR	0.68 (0.34–1.35)	0.57 (0.27–1.23)
Symptomatic ICH	OR	0.75 (0.12–4.64)	0.61 (0.08–4.76)

cOR, common odds ratio; OR, odds ratio; EE, effect estimate; EVT, endovascular treatment; ICH, intracranial hemorrhage; mRS, modified Rankin Scale; mTICI, modified Thrombolysis in Cerebral Infarction; and SAE, serious adverse event.

*Statistical significance.

Table 4. Regression Analyses Outcomes After Transforming Data

Stent retriever thrombectomy as first modality	Unadjusted percentage (95% CI)	Adjusted percentage (95% CI)
Procedure time (%)	−22.2 (−37.6 to −2.9)*	−26.2 (−41.9 to −6.2)*
Onset BAO to recanalization (%)	16.1 (−0.2 to 35.3)	3.4 (−9.7 to 18.2)

BAO indicates basilar-artery occlusion.

*Statistical significance.

symptomatic intracranial hemorrhage within 3 days post EVT, no statistical significant difference was seen.

Limitations

Although data were collected prospectively as part of a randomized controlled trial, our study has the limitations of a nonrandomized study, as the choice of endovascular approach, was left to the decision of the treating physician. The aim was to analyze differences between clinical and technical outcomes in patients treated with direct aspiration or stent retriever thrombectomy as first choice. Treating physicians were, however, free to switch from direct aspiration to stent retriever and vice versa, whereas only first choice technique was registered. Additionally, Abdelrady et al. showed higher revascularization rates among patients treated with both stent retriever and direct aspiration thrombectomy based on the frontline EVT strategy.[22] This might overestimate the effect of stent retriever thrombectomy, because the combined technique as first choice treatment is registered as stent retriever technique. However, our sensitivity analysis showed no difference in outcome excluding patients treated with the combined technique.

Another limitation is the change of first choice treatment over the years. Direct aspiration thrombectomy was more frequently used in the last years of the study (Figure S1). Better outcomes after aspiration thrombectomy could therefore simply reflect the increased experience of intervention teams over time. However, additional adjusting for treatment year showed no differences in favorable functional outcome and mRS score at 90 days (Table S4).

Finally, different generations of stent retrievers were used during the study period; there are limited data on functional and technical outcomes in patients treated with different stent retrievers. One study concluded no better clinical outcomes nor higher revascularization rates in patients treated with Trevo compared with Solitaire stent retrievers.[23] The influence of these different stent retrievers on technical outcomes, however, is still not known.

CONCLUSIONS

This study shows no difference in favorable functional outcome in patients with a BAO treated with direct aspiration compared with patients treated with stent retriever thrombectomy within the BASICS trial, despite a shorter procedure time and lower mortality rate at 90 days.

ARTICLE INFORMATION

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Disclosures

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Supplemental Materials

Supporting Information

REFERENCES

1. Demel SL, Broderick JP. Basilar occlusion syndromes: an update. *Neurohospitalist*. 2015;5:142-150. https://doi.org/10.1177/1941874415583847
2. Hawkes MA, Blaginykh E, Ruff MW, Burrus T, Wijdicks EFM, Rabinstein AA. Long-term mortality, disability and stroke recurrence in patients with basilar artery occlusion. *Eur J Neurol*. 2020;27:579-585. https://doi.org/10.1111/ene.14126
3. Zafar M, Mussa M, Memon RS, Nadeem S, Usman MS, Siddiqi J, Norbash A, Khosa F, Figueredo VM, Krasuski R, et al. Aspiration thrombectomy versus stent retriever thrombectomy alone for acute ischemic stroke: a systematic review and meta-analysis. *Cureus*. 2020;12:e8380. https://doi.org/10.7759/cureus.8380
4. Goyal M, Menon BK, van Zwam WH, Dippel DW, Mitchell PJ, Demchuk AM, Davalos A, Majoie CB, van der Lugt A, de Miquel MA, et al. Endovascular thrombectomy after large-vessel ischaemic stroke: a meta-analysis of individual patient data from five randomised trials. *Lancet*. 2016;387:1723-1731. https://doi.org/10.1016/S0140-6736(16)00163-X
5. Kang DH, Park J. Endovascular stroke therapy focused on stent retriever thrombectomy and direct clot aspiration: historical review and modern application. *J Korean Neurosurg Soc*. 2017;60:335-347. https://doi.org/10.3340/jkns.2016.0809.005
6. Bernsen MLE, Goldhoorn RB, Lingsma HF, van Oostenbrugge RJ, van Zwam WH, Uyttenboogaart M, Roos Y, Martens JM, Hofmeijer J, MR CLEAN Registry investigators*. Importance of occlusion site for thrombectomy technique in stroke: comparison between aspiration and stent retriever. *Stroke*. 2021;52:80-90. https://doi.org/10.1161/STROKEAHA.120.030031
7. Boulanger M, Lapergue B, Turjman F, Touze E, Anxionnat R, Bracard S, Piotin M, Gory B. First-line contact aspiration vs stent-retriever thrombectomy in acute ischemic stroke patients with large-artery occlusion in the anterior circulation: Systematic review and meta-analysis. *Interv Neuroradiol*. 2019;25:244-253. https://doi.org/10.1177/1591019918821074
8. Bernsen MLE, Bruggeman AAE, Brouwer J, Emmer BJ, Majoie C, Coutinho JM, Goldhoorn RB, van Oostenbrugge RJ, van Zwam WH, van der Leij C, et al. Aspiration versus stent retriever thrombectomy for posterior circulation stroke. *Stroke*. 2021:STROKEAHA121034926. https://doi.org/10.1161/STROKEAHA.121.034926
9. Langezaal LCM, van der Hoeven E, Mont'Alverne FJA, de Carvalho JJF, Lima FO, Dippel DWJ, van der Lugt A, Lo RTH, Boiten J, Lycklama ANGJ, et al. Endovascular therapy for stroke due to basilar-artery occlusion. *N Engl J Med*. 2021;384:1910-1920. https://doi.org/10.1056/NEJMoa2030297
10. van der Hoeven EJ, Schonewille WJ, Vos JA, Algra A, Audebert HJ, Berge E, Ciccone A, Mazighi M, Michel P, Muir KW, et al. The Basilar Artery International Cooperation Study (BASICS): study protocol for a randomised controlled trial. *Trials*. 2013;14:200. https://doi.org/10.1186/1745-6215-14-200
11. Zaidat OO, Yoo AJ, Khatri P, Tomsick TA, von Kummer R, Saver JL, Marks MP, Prabhakaran S, Kallmes DF, Fitzsimmons BF, et al. Recommendations on angiographic revascularization grading standards for acute ischemic stroke: a consensus statement. *Stroke*. 2013;44:2650-2663. https://doi.org/10.1161/STROKEAHA.113.001972
12. von Kummer R, Broderick JP, Campbell BC, Demchuk A, Goyal M, Hill MD, Treurniet KM, Majoie CB, Marquering HA, Mazya MV, et al. The Heidelberg Bleeding Classification: classification of bleeding events after ischemic stroke and reperfusion therapy. *Stroke*. 2015;46:2981-2986. https://doi.org/10.1161/STROKEAHA.115.010049
13. van der Hoeven EJ, McVerry F, Vos JA, Algra A, Puetz V, Kappelle LJ, Schonewille WJ, investigators Br. Collateral flow predicts outcome after basilar artery occlusion: the posterior circulation collateral score. *Int J Stroke*. 2016;11:768-775. https://doi.org/10.1177/1747493016641951
14. Ye G, Lu J, Qi P, Yin X, Wang L, Wang D. Firstline a direct aspiration first pass technique versus firstline stent retriever for acute basilar artery occlusion: a systematic review and meta-analysis. *J Neurointerv Surg*. 2019;11:740-746. https://doi.org/10.1136/neurintsurg-2018-014573
15. Gerber JC, Daubner D, Kaiser D, Engellandt K, Haedrich K, Mueller A, Puetz V, Linn J, Abramyuk A. Efficacy and safety of direct aspiration first pass technique versus stent-retriever thrombectomy in acute basilar artery occlusion-a retrospective single center experience. *Neuroradiology*. 2017;59:297-304. https://doi.org/10.1007/s00234-017-1802-6
16. Xenos D, Texakalidis P, Karras CL, Murthy NK, Kontzialis M, Rivet DJ, Reavey-Cantwell J. First-line stent retriever versus direct aspiration for acute basilar artery occlusions: a systematic review and meta-analysis. *World Neurosurg*. 2022;158:258-267.e1. https://doi.org/10.1016/j.wneu.2021.11.013
17. Alawieh A, Vargas J, Fargen KM, Langley EF, Starke RM, De Leacy R, Chatterjee R, Rai A, Dumont T, Kan P, et al. Impact of procedure time on outcomes of thrombectomy for stroke. *J Am Coll Cardiol*. 2019;73:879-890. https://doi.org/10.1016/j.jacc.2018.11.052
18. Lapergue B, Blanc R, Gory B, Labreuche J, Duhamel A, Marnat G, Saleme S, Costalat V, Bracard S, Desal H, et al. Effect of endovascular contact aspiration vs stent retriever on revascularization in patients with acute ischemic stroke and large vessel occlusion: the ASTER Randomized Clinical Trial. *JAMA*. 2017;318:443-452. https://doi.org/10.1001/jama.2017.9644
19. Sairanen T, Strbian D, Soinne L, Silvennoinen H, Salonen O, Artto V, Koskela I, Happola O, Kaste M, Lindsberg PJ, et al. Intravenous thrombolysis of basilar artery occlusion: predictors of recanalization and outcome. *Stroke*. 2011;42:2175-2179. https://doi.org/10.1161/STROKEAHA.110.605584
20. Smith ER, Bethel JA, Smith TB, Holden G, Torlak F, Grimsbo M, Seifi A, Mascitelli JR. Stent retriever versus direct aspiration thrombectomy for acute large vessel occlusion: a meta-analysis including 17,556 patients, from MR CLEAN to present. *Clin Neurol Neurosurg*. 2022;213:107122. https://doi.org/10.1016/j.clineuro.2022.107122
21. Primiani CT, Vicente AC, Brannick MT, Turk AS, Mocco J, Levy EI, Siddiqui AH, Mokin M. Direct aspiration versus stent retriever thrombectomy for acute stroke: a systematic review and meta-analysis in 9127 patients. *J Stroke Cerebrovasc Dis*. 2019;28:1329-1337. https://doi.org/10.1016/j.jstrokecerebrovasdis.2019.01.034

22. Abdelrady M, Ognard J, Cagnazzo F, Derraz I, Lefevre PH, Riquelme C, Gascou G, Arquizan C, Dargazanli C, Cheddad EI, et al. Frontline thrombectomy strategy and outcome in acute basilar artery occlusion. *J Neurointerv Surg*. 2022;15:27-33. https://doi.org/10.1136/neurintsurg-2021-018180

23. Mendonca N, Flores A, Pagola J, Rubiera M, Rodriguez-Luna D, De Miquel MA, Cardona P, Quesada H, Mora P, Alvarez-Sabin J, et al. Trevo versus solitaire a head-to-head comparison between two heavy weights of clot retrieval. *J Neuroimaging*. 2014;24:167-170. https://doi.org/10.1111/j.1552-6569.2012.00730.x