Aspiration Versus Stent Retriever Thrombectomy for Posterior Circulation Stroke

Stroke

CLINICAL AND POPULATION SCIENCES

Aspiration Versus Stent Retriever Thrombectomy for Posterior Circulation Stroke

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BACKGROUND AND PURPOSE: Whereas a clear benefit of endovascular treatment for anterior circulation stroke has been established, randomized trials assessing the posterior circulation have failed to show efficacy. Previous studies in anterior circulation stroke suggest that advanced thrombectomy devices were of great importance in achieving clinical benefit. Little is known about the effect of thrombectomy techniques on outcomes in posterior circulation stroke. In this study, we compare first-line strategy of direct aspiration to stent retriever thrombectomy for posterior circulation stroke.

METHODS: We analyzed data of patients with a posterior circulation stroke who were included in the Multicentre Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands Registry between March 2014 and December 2018, a prospective, nationwide study, in which data were collected from consecutive patients who underwent endovascular treatment for ischemic stroke in the Netherlands. We compared patients who underwent first-line aspiration versus stent retriever thrombectomy. Primary outcome was functional outcome according to the modified Rankin Scale. Secondary outcomes were reperfusion grade, complication rate, and procedure duration. Associations between thrombectomy technique and outcome measures were estimated with multivariable ordinal logistic regression analyses.

RESULTS: Overall, 71 of 205 patients (35%) were treated with aspiration, and 134 (65%) with stent retriever thrombectomy. Patients in the aspiration group had a lower pc-ASPECTS on baseline computed tomography, and general anesthesia was more often applied in this group. First-line aspiration was associated with better functional outcome compared with stent retriever thrombectomy (adjusted common odds ratio for a 1-point improvement on the modified Rankin Scale 1.94 [95% CI, 1.03–3.65]). Successful reperfusion (extended Thrombolysis in Cerebral Infarction ≥2B) was achieved more often with aspiration (87% versus 73%, P=0.03). Symptomatic hemorrhage rates were comparable (3% versus 4%). Procedure times were shorter in the aspiration group (49 versus 69 minutes P<0.001).

CONCLUSIONS: In this retrospective nonrandomized cohort study, our findings suggest that first-line aspiration is associated with a shorter procedure time, better reperfusion, and better clinical outcome than stent retriever thrombectomy in patients with ischemic stroke based on large vessel occlusion in the posterior circulation.

GRAPHIC ABSTRACT: A graphic abstract is available for this article.

Key Words: endovascular procedure ■ registries ■ reperfusion ■ stroke ■ suction ■ thrombectomy

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Nonstandard Abbreviations and Acronyms

eTICI	extended Thrombolysis in Cerebral Infarction
EVT	endovascular treatment
MR CLEAN	Multicentre Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands
mRS	modified Rankin Scale
NIHSS	National Institutes of Health Stroke Scale

Endovascular treatment (EVT) has been shown to be highly effective in anterior circulation stroke.[1] Recent trials testing the efficacy of EVT in posterior circulation stroke did not show a significant benefit.[2,3] The reason for this difference in treatment effect is unknown. Differences in vascular anatomy between the anterior and posterior circulation may play a role. The presence of a large number of small perforating arteries branching of the basilar artery supplying the brain stem may influence the effect of endovascular therapy.[4]

Stent retrievers were the most frequently used devices in anterior circulation trials. These are self-expanding stents that are deployed within the thrombus, pushing it aside and entangling it within the stent struts. When the clot is captured, the stent is carefully maneuvered out of the vessel. Theoretically, when the stent is deployed in the clot, clot material may be forced into these small vessels. Furthermore, the vessel wall may be damaged by the stent struts during stent retrieval. An alternative treatment approach, aspiration, uses suction to get hold on and remove the clot. Either the thrombus is ingested by aspiration alone, or it is affixed to the catheter, which is slowly withdrawn under continuous aspiration. The risk of occluding small perforating vessels by manipulation of the clot seems lower when compared with stent retriever. Also, less traction is exerted on the vasculature with thrombus withdrawal by aspiration catheters compared with stent retrievers, reducing the risk of endothelial damage.[5] Both thrombectomy methods have proven to be safe and effective in patients with acute ischemic stroke in the anterior circulation.[6,7] Little is known about their efficacy in stroke caused by posterior circulation occlusion.[8–10]

The purpose of our current study is to compare first-line strategy of direct aspiration with first-line stent retriever thrombectomy about clinical outcome, reperfusion grade, duration of the EVT procedure, and complication rate in patients with posterior circulation ischemic stroke in routine clinical practice.

METHODS

Design

We analyzed patients who were included in the Multicentre Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands (MR CLEAN) Registry.[1] The MR CLEAN Registry is a prospective, observational registry of all patients who underwent EVT as part of routine clinical practice (defined as entry into the angiography suite and arterial puncture) in the Netherlands since the completion of the MR CLEAN trial in 2014. Data about patient characteristics, intervention procedure, complications, reperfusion grade, and clinical outcome are recorded. Data of patients included up to December 31, 2018 are processed and used in our analysis. The MR CLEAN Registry was approved by the medical ethics committee. Data cannot be made available, as no patient approval has been obtained for sharing coded data. However, syntax files and output of statistical analyses in SPSS will be made available upon reasonable request.

Patients

We included patients with an intracranial proximal occlusion in the posterior circulation (basilar artery, intracranial part of the vertebral artery, and posterior cerebral artery) demonstrated by computed tomography (CT) angiography, who underwent EVT with either direct aspiration or stent retriever as first-line approach. Patients treated with intra-arterial thrombolysis only, or with a MERCI device or other modality, were excluded. We included all patients 18 years and older, regardless of time of symptom onset or last seen well.

Two observers read all discharge letters and clinical records to estimate time of large vessel occlusion. In case the observers did not agree, a third (a vascular neurologist) made the final decision.

Outcomes

Primary outcome measure was functional outcome on the modified Rankin Scale (mRS) score at 3-month follow-up, ranging from 0 (no symptoms) to 6 (dead). A trained research nurse assessed mRS at 90 days. Secondary outcomes were reperfusion grade according to the extended Thrombolysis in Cerebral Infarction (eTICI) scale score at end of the procedure, complication rate, and time to reperfusion. Reperfusion status was evaluated on digital subtraction angiography according to the eTICI score. eTICI ranges from grade 0 (no reperfusion) to grade 3 (complete reperfusion). Successful reperfusion was defined as eTICI 2B-3, excellent reperfusion as eTICI 2C-3. We also assessed rescue treatment if first treatment method did not result in successful reperfusion.

Complications that occurred during EVT, hospital admittance, or the 3-month follow-up period, were registered and evaluated by the serious adverse event committee. Medical records were searched for complications to prevent underreporting. These complications included symptomatic intracranial hemorrhage, progression of ischemic stroke (resulting in an increase of at least 4 points on the National Institutes of Health Stroke Scale [NIHSS]), new ischemic stroke, extracranial hemorrhage, and death. Intracranial hemorrhage was considered symptomatic if the patient had died or had deteriorated neurologically (an increase of at least 4 points on the NIHSS) and the hemorrhage was related to the clinical deterioration (according to Heidelberg criteria[11]). Symptomatic intracranial hemorrhage was assessed by the serious adverse event committee after evaluation of medical reports and imaging assessment.

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Imaging Assessment

Relevant imaging datasets (baseline noncontrast CT), baseline CT angiography, interventional Digital Subtraction Angiography, and follow up imaging, if applicable) were collected, anonymized and stored in an imaging database. An imaging core laboratory evaluated, in separate sessions, posterior circulation Alberta Stroke Program Early CT Score on baseline noncontrast CT, clot location and collateral status on baseline CT angiography, eTICI on digital subtraction angiography, and presence of intracranial hemorrhage on follow up CT.

The posterior circulation collateral score scoring system was used to assess the collateral status.[12] Collateral score ranges from 0 (bad collaterals) to 10 (good collaterals). The posterior circulation collateral score is a 10-point grading system, in which 1 point is scored for each patent collateral; posterior inferior cerebellar artery, anterior inferior cerebellar artery, superior cerebellar artery, and posterior communicating artery. When the diameter of the PCoA is equal or larger than the ipsilateral P1 segment, 2 points are allocated instead of 1 point. A fetal variant of the posterior cerebral artery was not included in the score.

Treatment

Patients were treated according to national guidelines for treatment of acute ischemic stroke, including intravenous thrombolysis, if indicated. Choice of clot retriever method was left to the attending physician's preference and registered in an intervention form. Rescue treatment was also recorded in the intervention form. Combined use of aspiration and stent retriever was not recorded and therefore not analyzed separately; in this analysis, it is considered a stent retriever approach. Procedure times were registered on an intervention form during and after the EVT.

Statistical Analyses

Continues data are presented as mean and SD, median and interquartile range. Categorical data are presented as frequencies and percentages (%). We compared baseline characteristics of patients with first-line aspiration and first-line stent retriever thrombectomy. Differences between the groups were tested with Pearsons χ^2 test in case of ordinal/nominal variables. All data sets with continuous variables were checked for normality of distribution using a normal probability plot. For comparison of continuous variables, we used the unpaired *T*-test combined with Levene test to check for homogeneity. In non-normal data, we used the Mann-Whitney *U* test. The level of significance was set at 0.05.

Multivariable ordinal logistic regression analysis was performed to investigate the effect of first-line treatment modality on clinical outcome (mRS) at 3 months. We corrected for intervention center, time from onset to groin, general anesthesia, NIHSS at baseline, posterior circulation Alberta Stroke Program Early CT Score on baseline CT, and collateral score on baseline CT. Relations were expressed as odds ratios with corresponding 95% CIs.

Missing Values

Missing NIHSS scores were retrospectively scored with a standardized score chart based on information from the reported neurological examination. If successful reperfusion was not achieved during EVT, the time of last contrast bolus injection was used as a proxy for duration of the procedure. If mRS at 3 months was not available, last observation was included. Any missing mRS scores were replaced by mRS scores derived from multiple imputation.[13] Multiple imputation was only used for regression analysis, not for descriptive analyses.

Analyses were performed with SPSS 26 for Macintosh.

RESULTS

In the MR CLEAN Registry, 264 patients with posterior circulation occlusion were registered between March 16, 2014 and December 31, 2018. From this analysis, 59 patients were excluded, mostly because only a digital subtraction angiography or catheterization was performed (n=40). The remaining 205 patients were included, of whom 71 (35%) were initially treated with aspiration and 134 (65%) with stent retriever (Figure 1).

Six of the 17 treatment centers most often used aspiration as first-line treatment modality (Table I in the Data Supplement). See Table II in the Data Supplement for an overview of used thrombectomy devices.

Baseline Characteristics

There were no significant differences in age, sex, cardiovascular risk factors, baseline NIHSS, or prestroke mRS between the aspiration and stent retriever groups (Table 1). Patients in the aspiration group had more extensive ischemia, expressed as lower, posterior circulation Alberta Stroke Program Early CT Score on baseline CT, and were more often treated under general anesthesia. Onset to groin puncture time and the distribution of occlusion sites between the 2 groups was not significantly different.

Functional Outcome

There was a significant difference in clinical outcome at 3 months between the 2 patient groups (Table 2). After correction for intervention center, collateral score, time from onset to groin, NIHSS baseline, posterior circulation Alberta Stroke Program Early CT Score, and use of general anesthesia, the adjusted common odds ratio for a shift of at least 1-point improvement on the mRS after treatment with aspiration as first treatment modality was 1.94 (95% CI, 1.03–3.65; Figure 2). Unadjusted odds ratio was 1.34 (95% CI, 0.79–2.29). In patients treated in the years 2017 and 2018, the difference was slightly larger (adjusted common odds ratio, 2.48 [95% CI, 1.19–5.17]; Figure I in the Data Supplement).

Technical Outcome

Higher reperfusion rates were seen in the aspiration first group and successful reperfusion was achieved more often in this group (87% versus 73%, $P<0.03$; Table 2; Figure 3). Excellent reperfusion was achieved in 62% in

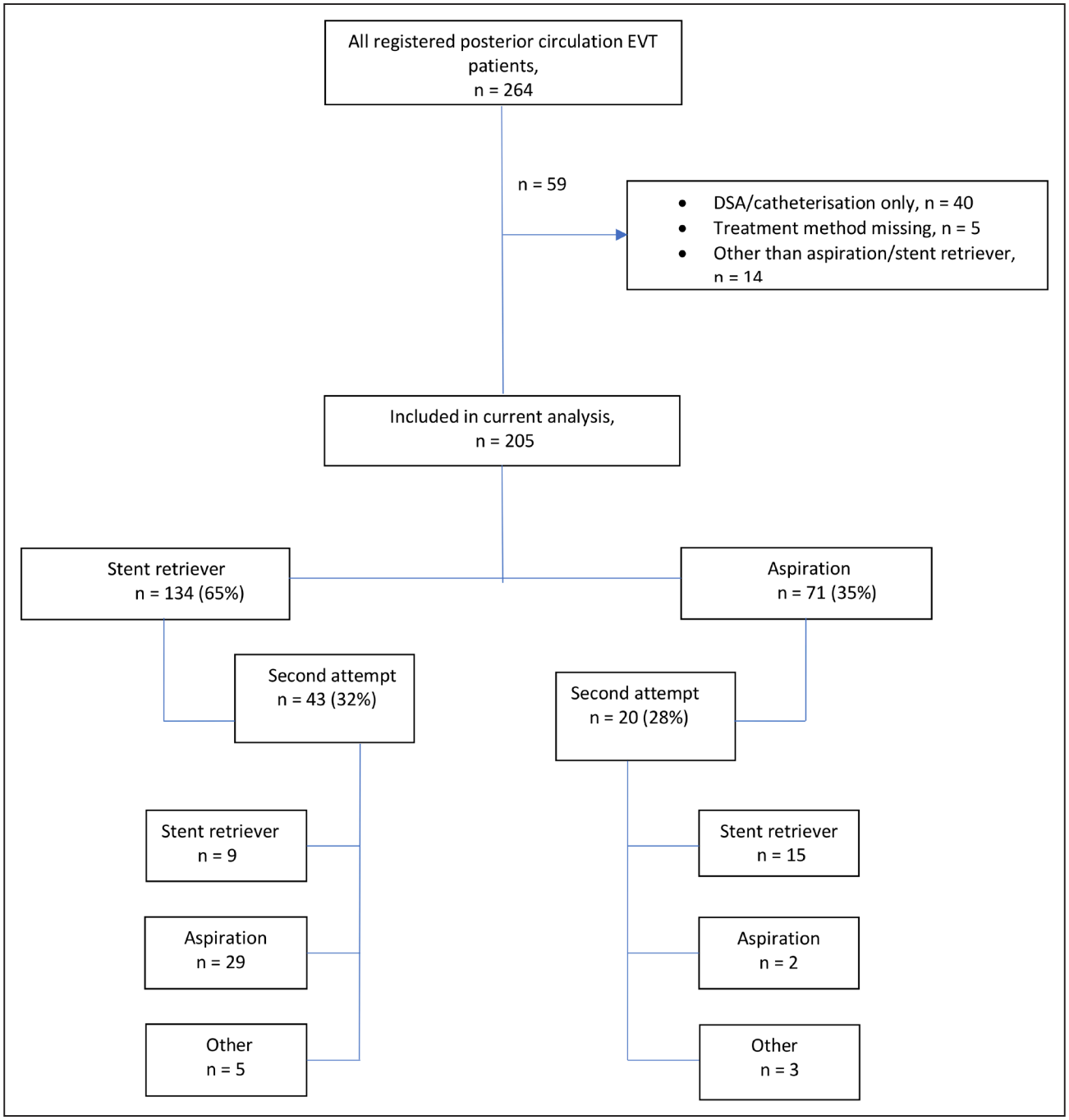

Figure 1. Flow of patients through this study.
DSA indicates digital subtraction angiography; and EVT, endovascular treatment.

the aspiration group and 48% in the stent retriever group (P=0.05). Procedure time was shorter in the aspiration group (49 versus 69 minutes, P<0.001).

Safety

There were no differences in the occurrence of symptomatic intracranial hemorrhage (3% aspiration group versus 4% stent retriever group, P=1.0) and serious adverse events (49% aspiration group and 55% stent retriever group, (P=0.56), nor was there a difference in mortality after 3 months (46% aspiration group and 42% stent retriever group, P=0.65) (Table 2).

First-Pass Reperfusion Rate and Rescue Treatment

First-pass successful reperfusion was achieved in 44 out of 71 patients (62%) in the aspiration group and in 66 patients (49%) in the stent retriever group (P=0.07). In the aspiration group, first pass was not successful in 27 patients. In 2 patients, treatment method was not altered

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Table 1. Baseline Characteristics

	Aspiration n=71		Stent retriever n=134		*P* value
Demographics					
Age, median (IQR)	60	(51–71)	66	(58–79)	0.13
Male, n (%)	41	(58%)	74	(55%)	0.77
NIHSS baseline, median (IQR)	19	(12–32)	20	(10–29)	1.0
Prestroke mRS, n (%)					0.81
0–2	63	(90%)	119	(91%)	
>2	7	(10%)	12	(9%)	
Medical history, n (%)					
Previous stroke	12	(17%)	23	(18%)	1.0
Myocardial infarction	9	(13%)	16	(12%)	0.82
Peripheral arterial disease	8	(12%)	6	(5%)	0.08
Atrial fibrillation	10	(14%)	19	(14%)	1.0
Cardiovascular risk factors, n (%)					
Hypertension	28	(41%)	68	(52%)	0.14
Hypercholesterolemia	16	(24%)	22	(17%)	0.26
Diabetes	13	(18%)	16	(12%)	0.29
Smoking	19	(37%)	25	(27%)	0.26
Medication use, n (%)					
Antiplatelet	21	(30%)	32	(25%)	0.51
Statin	17	(25%)	33	(26%)	0.87
Stroke characteristics					
Mean systolic blood pressure, mm Hg, mean (SD)	150	(26)	149	(30)	0.12
IVT, n (%)	30	(42%)	67	(50%)	0.31
Level of occlusion on CTA, n (%)					0.3
Intracranial vertebral artery	3	(4%)	5	(4%)	
Basilar artery	35	(51%)	47	(36%)	
Basilar artery extending in PCA	24	(35%)	55	(42%)	
PCA alone	6	(9%)	21	(16%)	
pc-ASPECTS subgroups, n (%)					0.05
0–4	2	(3%)	3	(2%)	
5–7	10	(14%)	6	(5%)	
8–10	59	(83%)	122	(93%)	
Collateral score on CTA, n (%)					0.09
Poor collaterals (<7)	38	(55%)	51	(40%)	
Moderate collaterals (8, 9)	28	(41%)	70	(53%)	
Good collaterals (10)	3	(4%)	10	(7%)	
Stroke cause, n (%)					0.42
Large artery atherosclerosis	24	(34%)	39	(29%)	
(Cardio) embolism	14	(20%)	41	(31%)	
Arterial dissection	7	(10%)	11	(8%)	
Undetermined/other/unknown	26	(37%)	43	(32%)	
Workflow					
Transfer from primary stroke center, n (%)	34	(48%)	55	(41%)	0.38
Onset to groin, min, median (IQR)	230	(155–367)	262	(128–383)	0.3
General anesthesia, n (%)	47	(66%)	68	(52%)	0.05

Continuous data are presented as mean (SD) for normally distributed data or as median (IQR) for skewed data. *P* value concern differences between patients treated with stent retriever first and direct aspiration first. EVT indicates endovascular treatment; IQR, interquartile range; IVT, intravenous thrombolysis; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; PCA, posterior cerebellar artery; and pc-ASPECTS, Alberta Stroke Program Early CT Score.

Table 2. Outcomes, Complications

	Aspiration, n=71		Stent retriever, n=134		*P* value
Duration of procedure in minutes, median (IQR)	49	(34–70)	69	(45–105)	<0.001
Time from estimated onset to; successful recanalization or last contrast bolus, median (IQR)	280	(195–420)	334	(233–452)	0.06
Post-EVT eTICI, n (%)					0.03
0	5	(7%)	11	(9%)	
1	0	(0%)	9	(7%)	
2A	4	(6%)	15	(12%)	
2B	17	(25%)	32	(25%)	
2C	9	(13%)	14	(11%)	
3	34	(50%)	47	(37%)	
Successful reperfusion (eTICI 2B-3), n (%)	60	(87%)	93	(73%)	0.03
Excellent reperfusion (eTICI 2C-3), n (%)	43	(62%)	61	(48%)	0.05
First pass successful reperfusion (eTICI 2B-3), n (%)	44	(62%)	66	(49%)	
mRS 3-mo follow-up (or last observation*), n (%)					0.04
0	7	(10%)	4	(3%)	
1	10	(15%)	12	(9%)	
2	13	(19%)	23	(17%)	
3	5	(8%)	19	(15%)	
4	2	(3%)	9	(7%)	
5	0	(0%)	10	(8%)	
6	31	(46%)	55	(42%)	
SAE any,† n (%)	35	(49%)	73	(55%)	0.56
sICH total, n (%)	2	(3%)	5	(4%)	1.0
Mortality, n (%)	31	(46%)	55	(42%)	0.65

eTICI indicates extended Thrombolysis in Cerebral Infarction; EVT, endovascular treatment; IQR, interquartile range; mRS, modified Rankin Scale; SAE, serious adverse event; and sICH, symptomatic intracranial hemorrhage.

*In 2 patients last observations was within 3 mo (one aspiration group, mRS score=0 and one stent retriever group mRS score=1).

†Serious adverse events included stroke progression resulting in neurodetoriation or death, new ischemic stroke resulting in neurodetoriation or death, symptomatic intracranial hemorrhage, extracranial hemorrhage, cardiac ischemia, allergic reaction, and pneumonia or other infection.

after an unsuccessful first pass, with successful reperfusion after a second aspiration attempt in 1. The interventionalist switched to stent retriever after an unsuccessful aspiration attempt in 15 (75%) patients. Successful reperfusion was achieved in 13 of these patients (87%). In 10 patients, the procedure was discontinued or another method was used (eg, intraarterial thrombolysis).

In the stent retriever group after an unsuccessful first pass, treatment method was not altered in 9 patients, with successful reperfusion after a second stent retriever attempt in 5 patients (56%). After initial treatment failure in the stent retriever group, a second attempt was made with aspiration in 29 patients (67%). Successful reperfusion was achieved in 20 patients (69%) after this second attempt. In 30 patients, the procedure was discontinued or another method than stent retriever or aspiration was used.

DISCUSSION

First-line aspiration thrombectomy showed better clinical outcomes than first-line stent retriever thrombectomy in patients with posterior circulation ischemic stroke. Aspiration was associated with shorter procedure times and higher recanalization rates. There was no difference in safety outcomes.[8,14]

Clinical Outcome

There are limited data available of the comparison between aspiration and stent retriever thrombectomy in posterior circulation stroke. In a recent meta-analysis by Sheng et al no statistically significant outcome differences were observed; however, results from older studies, before the widespread use of next generation devices, are also reflected in this meta-analysis.[10] Other observational studies show comparable clinical outcomes with similar safety profiles.[10] Higher reperfusion rates and shorter procedure times with aspiration have repeatedly been demonstrated in nonrandomized studies in anterior circulation stroke and basilar artery occlusion.[8,15] Apparent better clinical outcome with aspiration first may be related to shorter procedure times and numerically higher rates of first pass successful reperfusion, as these play an important role in achieving favorable outcomes

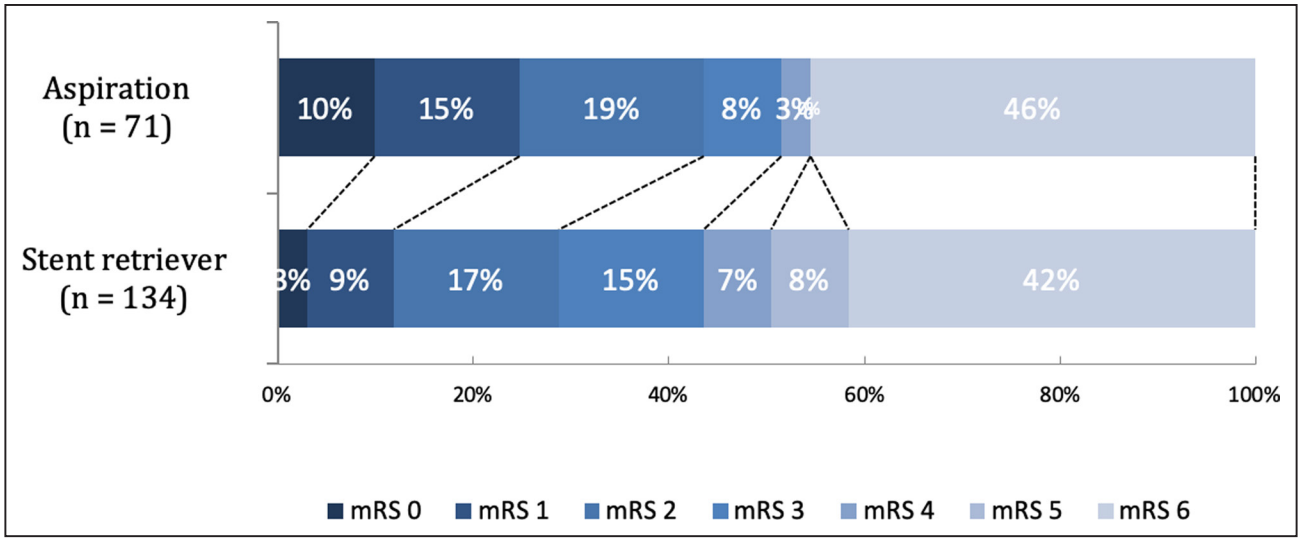

Figure 2. Distribution of scores on the modified Rankin Scale for the aspiration and stent retriever groups.
There is a significant difference between the groups in the overall distribution of scores in an analysis with multivariable ordinal regression. After adjustment for intervention center, collateral score, time to groin, National Institutes of Health Stroke Scale baseline, ASPECTS score, and general anesthesia, there was a shift in the modified Rankin Scale (mRS) distribution in favor of the aspiration first strategy, with an adjusted common odds ratio for a 1-point improvement of score on the mRS of 1.94 (95% CI, 1.03–3.65).

in patients undergoing mechanical thrombectomy for stroke.[16–18] The anatomy of the basilar artery may add to the favorable effects of aspiration. Theoretically, with aspiration, there is less damage to the vessel wall and a smaller risk of occlusion of small perforating vessels.[5]

Probably, the vulnerability of the brain stem area, the fragile anatomy of the basilar artery and its many small side branches, combined with the shorter procedure times translates the benefits of aspiration into better functional outcome in posterior circulation infarcts. When analyzing patients treated in 2017 and 2018, we see that differences in clinical outcome become more prominent. Next generation aspiration catheters hold potential to provide even better clinical outcome.

Complications

Some previous studies show more procedural complications in posterior circulation than in anterior circulation stroke.[19] Higher rates of intracranial arteriosclerotic

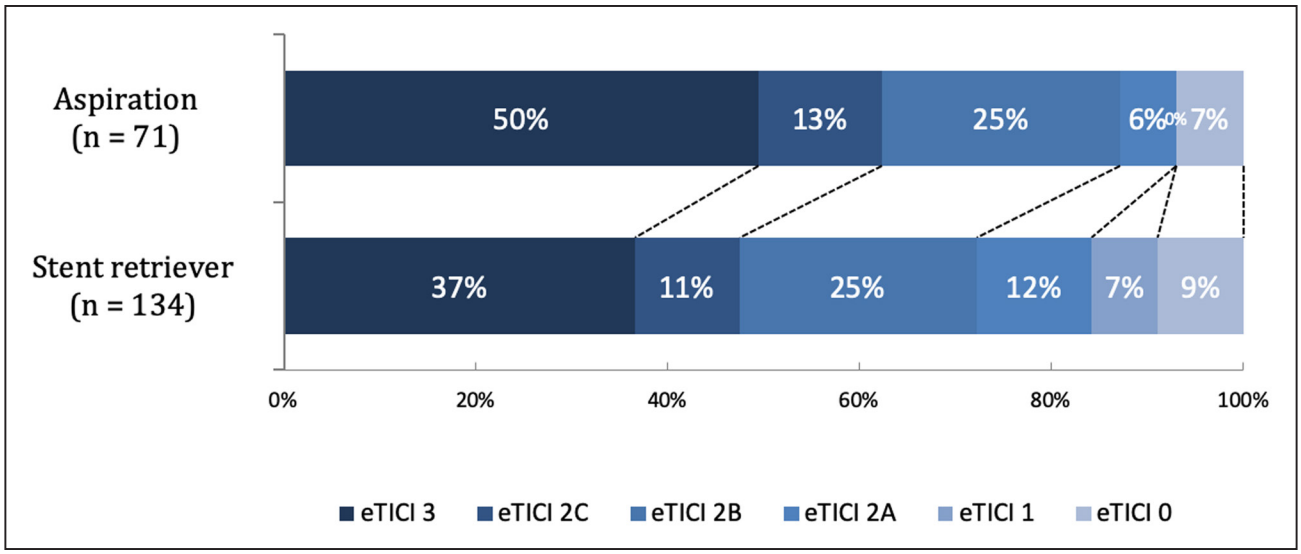

Figure 3. Distribution of extended Thrombolysis in Cerebral Infarction (eTICI) scores at the end of the procedure for the aspiration and stent retriever groups.
There is a difference between the groups in the overall distribution of eTICI scores at the end of all endovascular procedures in favor of the aspiration group. Grade 0: no perfusion, Grade 1: penetration with minimal perfusion, Grade 2: partial perfusion, Grade 2A: only partial filling (less than two-thirds) of the entire vascular territory is visualized, Grade 2B: complete filling of all of the expected vascular territory is visualized but the filling is slower than normal, Grade 2C: slow flow in a few distal cortical vessels or presence of small distal cortical emboli, corresponding to 90% to 99% reperfusion. Grade 3: complete perfusion.

disease in posterior circulation stroke, underlying atherosclerotic stenosis, and smaller vessel lumen may cause this higher complication rate. When we compare our complication rate with anterior circulation stroke patients in the MR CLEAN Registry treated with aspiration or stent retriever, we notice essentially equal rates of intracranial hemorrhage.[15] There were no differences in symptomatic intracranial hemorrhage or any adverse events between the aspiration and stent retriever groups, nor was there a difference in mortality. Safety profile of EVT in the current analysis corresponds to those reported for the BASICS trial.[3]

Limitations

This is a retrospective observational study with prospectively collected data, and although we adjusted for potential confounders, any bias cannot be excluded. We analyzed differences in outcome in relation to initial thrombectomy technique in a real-life setting. If the initial approach failed, the interventionalist could switch to another method to achieve successful reperfusion. As a consequence, in both groups, successful reperfusion was sometimes achieved by the other method.

There were few differences in baseline characteristics between the 2 groups. Most relevant were the use of general anesthesia and the early signs of ischemia on baseline CT. We corrected for these factors in our multivariable analysis. The main limitation of our study is the nonrandomized nature. Interventionist could be influenced by the vascular anatomy in their first choice of thrombectomy technique. Aspiration, requiring distal deployment of large bore catheters, may be the preferred treatment option in case of a less complicated vascular anatomy, causing a selection bias toward patients with a potentially better prognosis.

Thrombectomy method changed over the course of time. At the start of the MR CLEAN registry, stent retrievers were by far the most used devices. Over time, aspiration catheters were increasingly used. In 2018, numbers of patients treated with stent retriever and aspiration were almost equal (Figure II in the Data Supplement). Although this could entail a learning effect by the interventionalist, we found essentially similar results in the subgroup of patients treated in 2017 and 2018.

More research in the form of randomized trials is necessary to confirm our findings and to asses if aspiration thrombectomy leads to better clinical outcome compared with intravenous thrombolysis alone.

CONCLUSIONS

In this retrospective nonrandomized cohort study, our findings suggest that first-line aspiration is associated with a shorter procedure time, better reperfusion, and better clinical outcome than stent retriever thrombectomy in patients with ischemic stroke based on large vessel occlusion in the posterior circulation.

ARTICLE INFORMATION

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Supplemental Materials

Online Tables I–III
Online Figures I and II
Acknowledgments—MR CLEAN Registry investigators

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