Importance of occlusion site for thrombectomy technique in stroke: comparison between aspiration and stent retriever

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Stroke

CLINICAL AND POPULATION SCIENCES

Importance of Occlusion Site for Thrombectomy Technique in Stroke

Comparison Between Aspiration and Stent Retriever

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BACKGROUND AND PURPOSE: Thrombectomy with stent retriever and direct aspiration are equally effective in the endovascular treatment of anterior circulation acute ischemic stroke. We report efficacy and safety of initial treatment technique per occlusion segment.

METHODS: For this study, we analyzed data from the MR CLEAN Registry, a prospective, observational study in all centers that perform endovascular therapy in the Netherlands. We used ordinal logistic regression analysis to compare clinical and technical results of first line direct aspiration treatment with that of stent retriever thrombectomy stratified for occlusion segment. Primary outcome measure was functional outcome at 3 months. Secondary outcome measures included reperfusion grade expressed as the extended Thrombolysis in Cerebral Infarction score, periprocedural complication risk, time to reperfusion, and mortality.

RESULTS: Of the 2282 included patients, 1658 (73%) were initially treated with stent retriever and 624 (27%) with aspiration. Four hundred sixty-two patients had an occlusion of the intracranial part of the carotid artery, 1349 of the proximal middle cerebral artery, and 471 of the distal parts of the middle cerebral artery. There was no difference in functional outcome between aspiration and stent retriever thrombectomy (odds ratio, 1.0 [95% CI, 0.9–1.2]) in any of the occlusion segments (*P* value for interaction=0.2). Reperfusion rate was higher in the aspiration group (odds ratio, 1.4 [95% CI, 1.1–1.6]) and did not differ between occlusion segments (*P* value for interaction=0.6). Procedure times were shorter in the aspiration group (minutes 50 versus 65 minutes; *P*<0.0001). There was no difference in periprocedural complications or mortality.

CONCLUSIONS: In unselected patients with anterior circulation infarcts, we observed equal functional outcome of aspiration and stent retriever thrombectomy in all occlusion segments. When aspiration was the first line treatment modality, reperfusion rates were higher and procedure times shorter in all occlusion segments.

Key Words: carotid arteries ■ endovascular procedure ■ middle cerebral artery ■ reperfusion ■ stent ■ stroke ■ thrombectomy

Stent retriever and direct aspiration thrombectomy are equally effective and safe in the endovascular treatment (EVT) of acute ischemic stroke.[1–5] However, safety and efficacy have not been compared in relation to the site of arterial occlusion.

Most patients with anterior circulation infarcts who are eligible for EVT have an occlusion in the proximal middle cerebral artery (MCA-M1).[6,7] Second most common occlusions are located in the more distal parts of the middle cerebral artery (MCA-M2) or in the intracranial part of the carotid artery (IC-ICA). Occlusions in the anterior cerebral artery are relatively rare.

It has been suggested that stent retrievers are especially effective in patients with proximal occlusions, such as internal carotid artery and M1 occlusions.[8] More distal occlusion sites have been associated with longer procedure times

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Nonstandard Abbreviations and Acronyms

ASPECTS	Alberta Stroke Program Early CT Score
eTICI	extended Thrombolysis in Cerebral Infarction
EVT	endovascular treatment
IC-ICA	intracranial part of the carotid artery
IVT	intravenous thrombolysis
MCA-M1	proximal middle cerebral artery
MCA-M2	distal parts of the middle cerebral artery
mRS	modified Rankin Scale
NIHSS	National Institutes of Health Stroke Scale
SAE	serious adverse event
sICH	symptomatic intracranial hemorrhage

and a higher risk of complications.[9,10] Other studies showed equal reperfusion rates, complication rates, and procedure times for direct aspiration thrombectomy in patients with M1 and M2 occlusions.[10] Data from the recent ASTER trial (The Contact Aspiration vs Stent Retriever for Successful Revascularization) suggest that aspiration may be preferable with more distal anterior circulation occlusions, but patient numbers were too small to provide definite answers.[1]

The objective of our current study is to analyze the effect of thrombectomy technique in different occlusion segments, that is, IC-ICA, MCA-M1, or MCA-M2, according to whether aspiration or stent retriever was used first.

METHODS

Design

We analyzed differences between groups of patients who were included in the MR CLEAN Registry (Multicenter Randomized Clinical Trial of Intra-Arterial Treatment for Acute Ischemic Stroke in the Netherlands).[7] The MR CLEAN Registry is a prospective, observational study in all centers that perform EVT in the Netherlands. In this registry, which started following the conclusion of the MR CLEAN trial on March 16, 2014, all patients undergoing EVT (defined as entry into the angiography suite and arterial puncture) are registered. Data about patient characteristics, intervention procedure, complications, reperfusion grade, and clinical outcome are recorded. Data of patients who were treated up to November 1, 2017 in centers that participated in the MR CLEAN trial were processed and used in this 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 on request.

Patients

In the current analysis, we included patients who underwent first line thrombectomy treatment with direct aspiration or stent retriever. Patients treated with intra-arterial thrombolysis only, or those who were treated with a MERCI (Mechanical Embolus Removal for Cerebral Ischemia) device or other modality, were excluded. Other inclusion criteria for this study were age 18 years and older, intracranial proximal arterial occlusion in the anterior circulation (IC-ICA or MCA-M1/M2) demonstrated by computed tomography (CT) angiography, and arterial puncture within 6.5 hours of symptom onset.[7] Predefined subgroups were based on occlusion segment scored on digital subtraction angiography and consisted of (1) IC-ICA occlusion, (2) MCA-M1 occlusion, and (3) MCA-M2 occlusion. Patients with an occlusion in the anterior cerebral artery or other/multiple segments were excluded because of expected low numbers or lack of specific data availability.

Outcome Measures

Primary outcome measure was functional outcome on the modified Rankin Scale (mRS) at 90 days, ranging from 0 (no symptoms) to 6 (dead). Secondary outcome measures were reperfusion grade according to the extended Thrombolysis in Cerebral Infarction (eTICI) scale at the end of the interventional procedure, complication rate, and time to reperfusion. The eTICI score ranges from 0 (no antegrade reperfusion of the occluded vascular territory) to 3 (complete antegrade reperfusion). Successful reperfusion was defined as eTICI 2B-3. Excellent reperfusion was defined as eTICI 2C-3. To reach an eTICI score of 2B or higher (ranging from at least 50% reperfusion to complete filling of the affected vascular territory), complete digital subtraction angiography runs including anteroposterior and lateral views after thrombectomy were mandatory. If a lateral view was missing, 2A was the highest possible score.

Relevant imaging datasets (baseline noncontrast CT, baseline CT angiography, interventional digital subtraction angiography, and follow up imaging, if applicable) were collected, anonymized, stored in an imaging database (XNAT; NRG, St. Louis, MO), and subsequently analyzed by an imaging core laboratory. Observers were blinded to all clinical findings, with exception of clinical assessment of lesion location in the case of baseline noncontrast CT. In separate sessions, the core laboratory evaluated Alberta Stroke Program Early CT Score (ASPECTS) on baseline CT, eTICI on digital subtraction angiography, and presence of intracranial hemorrhage on follow up CT.

Complications that occurred during intervention, hospital admittance, or in 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 included 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 on follow-up imaging was classified according to the Heidelberg criteria[11] and 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). Symptomatic intracranial hemorrhage (sICH) was assessed by the serious adverse event committee after evaluation of medical reports and imaging assessment.

Treatment

Patients were treated according to national guidelines for treatment of acute ischemic stroke, including intravenous thrombolysis (IVT) if indicated. Choice of thrombectomy method was left to the attending physician's preference. Direct aspiration was defined as aspiration with a syringe or mechanical pump on a large bore catheter near the occluding clot. The combined treatment of stent retriever and aspiration is not analyzed separately; in this analysis it is considered a stent retriever approach.

Statistical Analyses

Baseline characteristics are presented in a descriptive way as mean and SD, median and interquartile range, or frequency and percentage (%). Patients who underwent first treatment attempt with aspiration were compared with patients who underwent first treatment attempt with stent retriever thrombectomy. Differences between the groups were tested with Pearson's 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 and the Kolmogorov-Smirnov test. For comparison of continuous variables, we used the unpaired T-test combined with Levene test to check for homogeneity. If the distribution was not normal, we used the Mann-Whitney *U* test. The level of significance was set at 0.05.

Ordinal logistic regression analysis was used to estimate the effect of first line treatment modality on clinical and technical outcome for the whole group and for the subgroups based on occlusion segment. To test for interaction between thrombectomy method and occlusion segment on functional and technical outcome, we added a multiplicative interaction term to the regression models.

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 the last contrast bolus injection was used as a proxy for time of duration of the procedure. Any mRS score of 0 to 5 assessed within 30 days after EVT was considered not valid and treated as missing. These values were therefore replaced by mRS scores derived from multiple imputation.[12] All descriptive analyses include all patients without imputation of the data. To make unbiased estimates of associations between intervention and outcome, multiple imputation was performed with the following variables: age, sex, baseline NIHSS score, diabetes, previous myocardial infarction, previous stroke, prestroke mRS score, atrial fibrillation, IVT before EVT, systolic blood pressure, baseline ASPECTS, CT angiography collateral status, time from symptom onset to start of EVT, time from symptom onset to successful reperfusion, eTICI score at the end of the intervention, and NIHSS score after 24 to 48 hours.

All analyses were performed with SPSS 24 for Macintosh.

RESULTS

In the MR CLEAN registry, 3637 patients were registered between March 16, 2014 and November 1, 2017. For our analysis, 1355 patients were excluded (Figure 1). Most of these (476) underwent catheterization only without thrombectomy, either because the target occlusion had resolved, or the clot had migrated distally. Eighty excluded patients had an occlusion in the anterior cerebral artery (n=7), extracranial-ICA (n=35), MCA-M3, MCA-M4, in multiple segments, or in another segment (n=38).

Four of the 16 intervention centers used aspiration as preferred first line strategy (Table I in the Data Supplement).

Of the 2282 patients who were included, 624 (27%) were initially treated with aspiration and 1658 (73%) with stent retriever. Most had an occlusion in the MCA-M1 segment (1349 patients [59%]), followed by 471 patients (21%) who had an occlusion in the MCA-M2 segment, and 462 patients (20%) with an occlusion in the IC-ICA.

Baseline Characteristics

There were no significant differences in age, sex, baseline NIHSS, and prestroke mRS between the aspiration and stent retriever groups (Table 1). Hypercholesterolemia was more often encountered in patients in the aspiration group and in this group more patients received IVT before EVT. Balloon guiding was used less in the aspiration group and general anesthesia was more frequently applied (41% versus 20%). Furthermore, duration from onset to groin was shorter in the aspiration group (195 versus 185 minutes). There were small differences in the distribution of occlusion sites between first line treatment modality. In the aspiration group, 21% of the patients had an IC-ICA occlusion, 55% a MCA-M1 occlusion, and 23% a MCA-M2 occlusion. In the stent retriever group, these percentages were 20%, 60%, and 20%, respectively.

Functional Outcome

None of the subgroups according to occlusion segment showed a difference in functional outcome after aspiration or stent retriever thrombectomy (*P* value for interaction=0.2; Figure 2). Functional outcome after 3 months was essentially the same in the aspiration group compared with the stent retriever group (common odds ratio, 1.0 [95% CI, 0.9–1.2]). After correction for age, intervention center, collateral score, time to groin, IVT, NIHSS baseline, general anesthesia, and prestroke mRS this did not change (adjusted common odds ratio, 1.1 [95% CI, 0.9–1.3]).

Technical Outcome

In the aspiration group, reperfusion rate at the end of the procedure was significantly higher than in the stent retriever group (common odds ratio, 1.4 [95% CI, 1.2–1.6]). This difference remained after adjustment for age, intervention center, collateral score, time to groin, IVT, NIHSS baseline, general anesthesia, and prestroke mRS (adjusted common odds ratio, 1.3 [95% CI, 1.1–1.5]). This result applied to all

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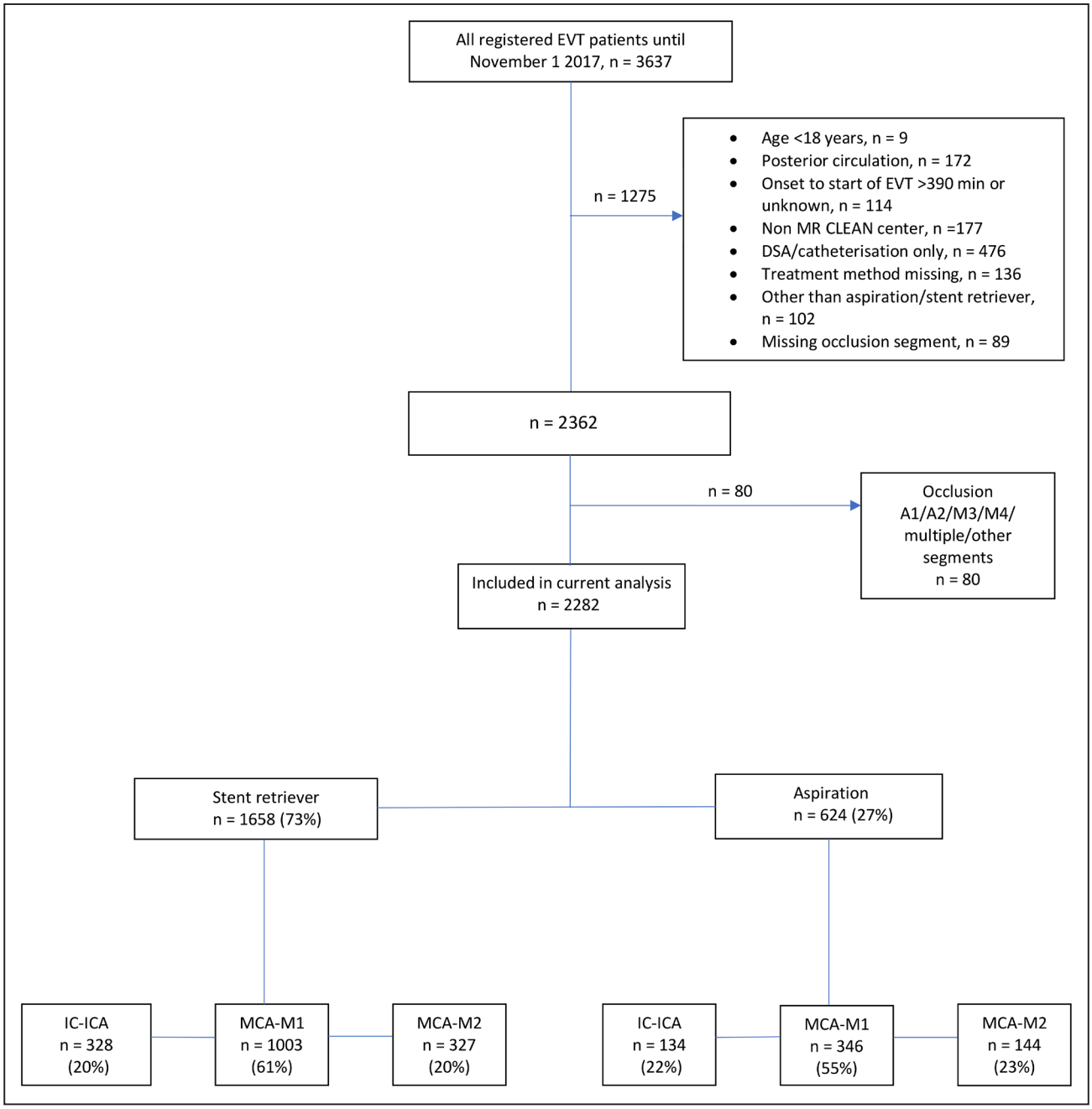

Figure 1. Flow of patients through this study.
DSA indicates digital subtraction angiography; EVT, endovascular treatment; IC-ICA, intracranial part of the carotid artery; MCA, middle cerebral artery; and MR CLEAN, Multicenter Randomized Clinical Trial of Intra-Arterial Treatment for Acute Ischemic Stroke in the Netherlands.

subgroups (*P* value for interaction=0.6; Figure 3, Table 2). Compared with the main analysis, we found similar results after additional correction for balloon guiding catheter use (adjusted common odds ratio, 1.3 [95% CI, 1.1–1.7])

First Pass Reperfusion Rate

First pass successful reperfusion was achieved in 334 patients (54%) in the aspiration group and in 794 patients (48%) in the stent retriever group (*P*=0.005). The difference between aspiration and stent retriever was more prominent in the M1 and M2 occlusion subgroups, but there was no statistically significant interaction with main effect.

Additional Treatment

The neurointerventionalist decided to continue the procedure after unsuccessful first aspiration attempt in 177 patients. A switch to stent retriever was made in 135 patients (76%) of which 71 patients (53%) achieved successful reperfusion. In 26 patients, treatment technique was not altered and another attempt

Table 1. Baseline Characteristics of Patients Treated With Direct Aspiration or Stent Retriever Thrombectomy

	Aspiration		Stent retriever		
	N=624		N=1658		*P* value
Demographics					
Age, median (IQR)	72	(62–80)	71	(61–79)	0.5
Male, n (%)	324	(52%)	855	(52%)	0.9
NIHSS baseline, median (IQR)	16	(12–20)	16	(12–20)	0.2
Prestroke mRS, n (%)					0.9
0–2	525	(84%)	1438	(87%)	
>2	72	(12%)	195	(12%)	
Medical history, n (%)					
Previous stroke	96	(15%)	283	(17%)	0.4
Myocardial infarction	93	(15%)	235	(14%)	0.6
Peripheral arterial disease	47	(8%)	163	(10%)	0.1
Atrial fibrillation	142	(23%)	406	(24%)	0.4
Cardiovascular risk factors, n (%)					
Hypertension	328	(53%)	852	(51%)	0.5
Hypercholesterolemia	211	(34%)	478	(29%)	0.02
Diabetes	89	(14%)	266	(16%)	0.3
Smoking	130	(21%)	354	(21%)	0.7
Medication use, n (%)					
Antiplatelet	205	(33%)	510	(31%)	0.3
Statin	212	(34%)	597	(36%)	0.5
Stroke characteristics, n (%)					
IVT performed	488	(78%)	1224	(74%)	0.03
Level of occlusion on CTA					0.08
ICA intracranial	134	(21%)	328	(20%)	
M1	346	(55%)	1003	(60%)	
M2	144	(23%)	327	(20%)	
ASPECTS subgroups					0.2
0–4	26	(4%)	87	(5%)	
5–7	144	(23%)	336	(20%)	
8–10	438	(70%)	1189	(72%)	
Collaterals on CTA					0.6
Absent collaterals	41	(7%)	97	(6%)	
Filling <50% of occluded area	219	(35%)	568	(34%)	
>50% but <100%	228	(37%)	615	(37%)	
Filling 100% of the occluded area	97	(16%)	294	(18%)	
Workflow					
Transfer from primary stroke center, n (%)	358	(57%)	903	(54%)	0.2
Onset to groin (min), median (IQR)	185	(149–235)	195	(150–255)	0.01
Balloon guiding use, n (%)	148	(24%)	1013	(61%)	<0.0001
General anesthesia, n (%)	258	(41%)	330	(20%)	<0.0001

ASPECTS indicates Alberta Stroke Program Early CT Score; CTA, CT angiography; ICA, internal carotid artery; IQR, interquartile range; IVT, intravenous thrombolysis; mRS, modified Rankin Scale; and NIHSS, National Institutes of Health Stroke Scale.

was made with direct aspiration. Successful reperfusion was achieved in 17 patients (65%). The remaining 16 patients were treated by another method (eg, intra-arterial thrombolysis).

After initial treatment failure in the stent retriever group, the neurointerventionalist converted treatment method to aspiration in 283 of the 484 patients (58%). Successful reperfusion was achieved in 166 patients (59%). In 118 patients, treatment method was not

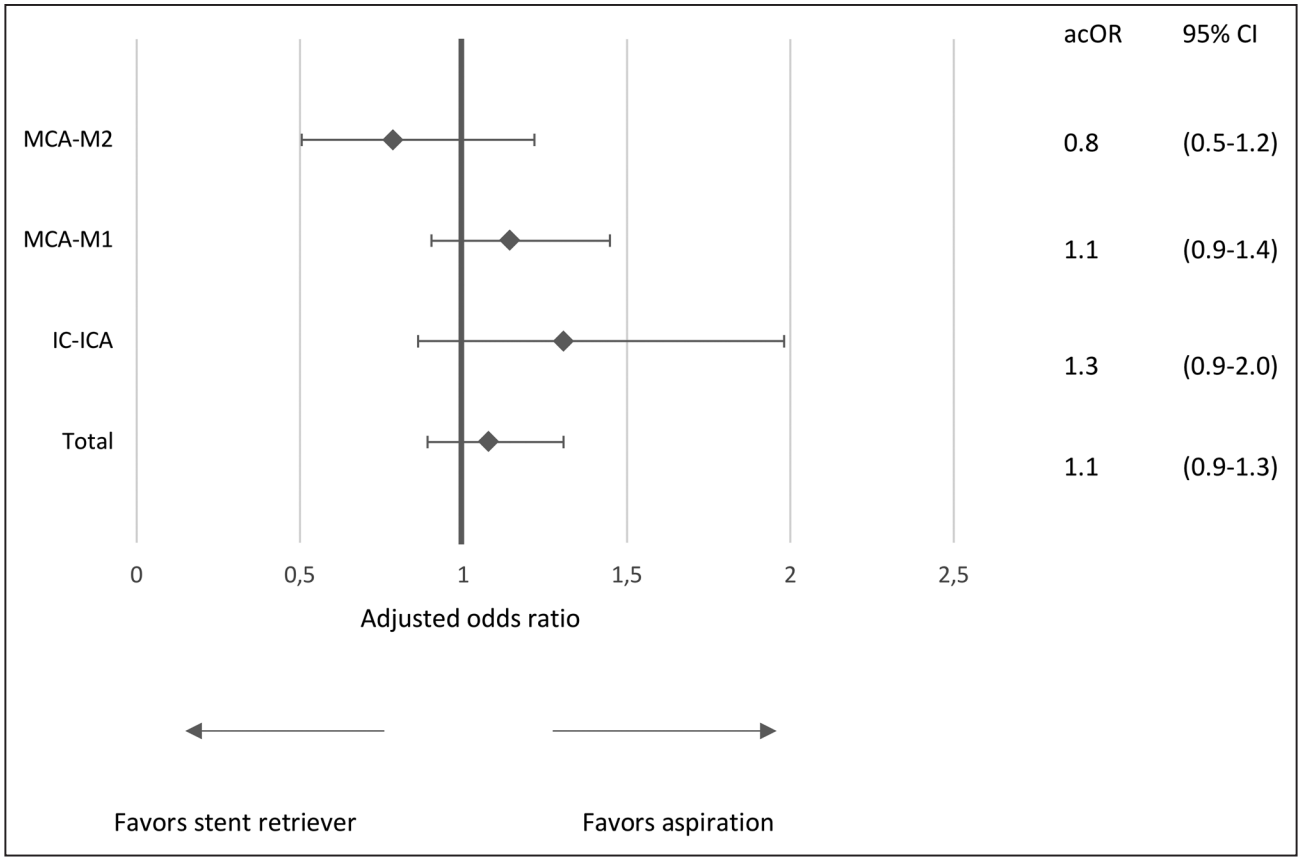

Figure 2. Forest plot showing odds ratio's for the shift toward a better functional outcome on the modified Rankin Scale (mRS) for subgroups of patients according to occlusion site.

There is no statistically significant difference between the groups in the overall distribution of scores in an analysis with univariable ordinal regression. There was no significant shift in the mRS distribution in favor of the aspiration strategy, with a cOR for a 1-point improvement of score on the mRS score of 1.0 (95% CI, 0.9–1.2). Results after adjustment for age, intervention center, collaterals, time to groin, National Institutes of Health Stroke Scale score at baseline, general anesthesia, and prestroke mRS in an analysis with multivariable regression are essentially the same (acOR, 1.1 [95% CI, 0.9–1.3]). *P* value for interaction is 0.2. acOR indicates adjusted common odds ratio; cOR, common odds ratio; IC-ICA, intracranial part of the carotid artery; and MCA, middle cerebral artery.

altered. In this group, successful reperfusion after second attempt was achieved in 40 patients (33%). In the remaining 83 patients, another treatment method was applied (Table 3).

Safety and Duration of the Procedure

There were no differences in the occurrence of sICH and stroke progression/new ischemic stroke resulting in neurodeterioration or death nor was there a difference in mortality after 3 months in any of the occlusion site subgroups (Table 2). When first stent retriever attempt was followed by another stent retriever attempt, sICH rate was the lowest (Table 3), this applied to all occlusion segments. Mortality was the highest in patients with an occlusion in the IC-ICA segment, regardless of the thrombectomy technique used.

The duration of the procedure was shorter in the aspiration group (50 versus 65 minutes, $P<0.0001$).

DISCUSSION

We observed no interaction between first line treatment modality and occlusion segment for both clinical and technical outcomes. In the overall group, no differences in clinical outcome between first line stent retriever treatment and aspiration were found. However, procedure time was shorter, and reperfusion rate was higher when aspiration was used as first-line strategy in all occlusion segments.

Our results are not fully in line with those from the ASTER trial, showing no benefits of aspiration over stent retriever thrombectomy in the IC-ICA, M1 and M2 occlusion segments.[1,13] The neutral results of the ASTER trial may be related to the fact that this trial was not powered to analyze the differences in outcomes per occlusion segment.

Though higher reperfusion rate is associated with better outcome, we did not see a difference in functional outcome between the aspiration and stent retriever group. This may result from heterogeneity of patient groups, where functional recovery depends on factors other than reperfusion, as well. It may also be related to a low specificity of the

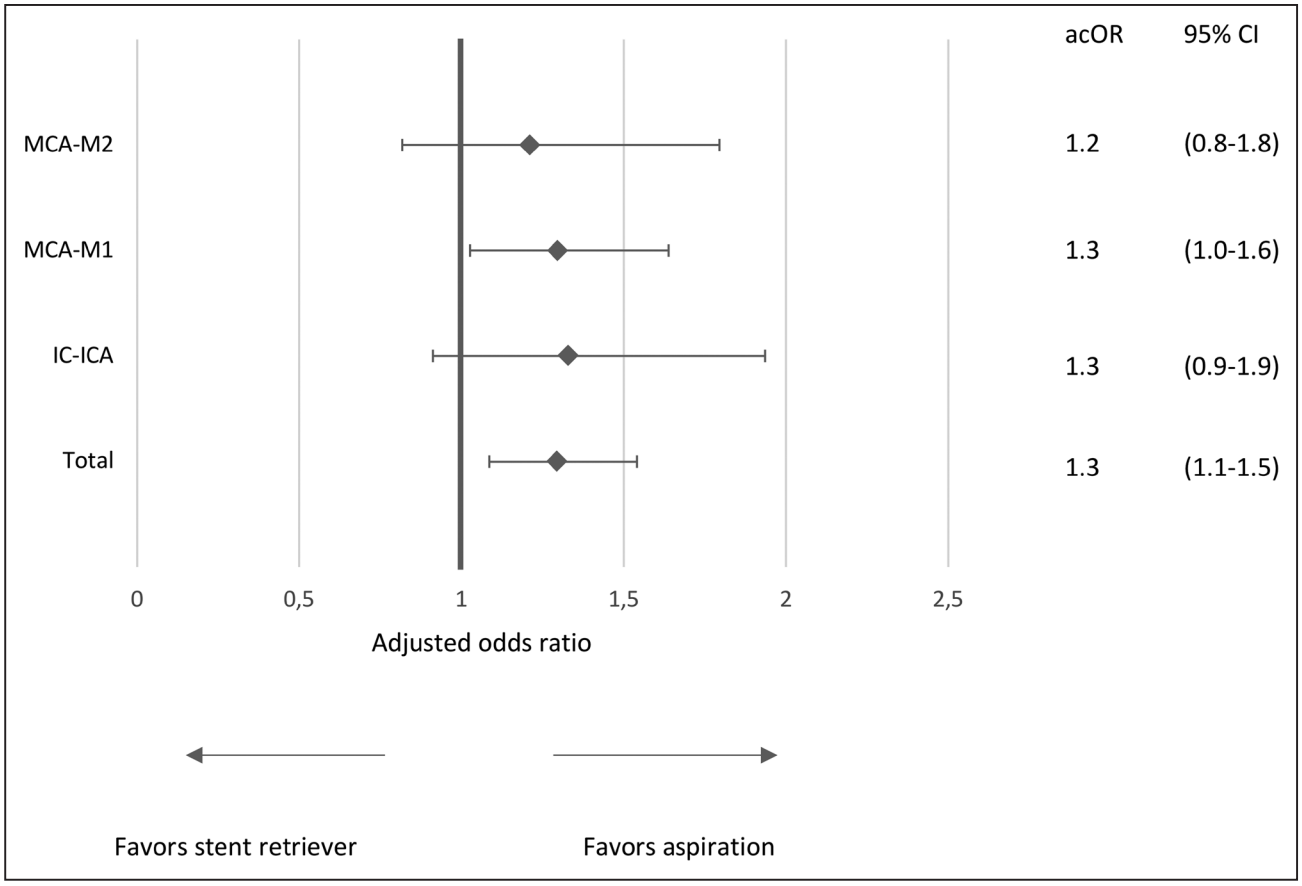

Figure 3. Forest plot showing odds ratios for the shift toward higher reperfusion rate.
There is a difference between the techniques in the overall distribution of extended Thrombolysis in Cerebral Infarction scores at the end of all endovascular procedures in favor of patients treated with direct aspiration (cOR, 1.4 [95% CI, 1.2–1.6]). After adjustment for age, intervention center, collateral score, time to groin, general anesthesia, intravenous thrombolysis, National Institutes of Health Stroke Scale score at baseline, and prestroke modified Rankin Scale, this did not change (acOR, 1.3 [95% CI, 1.1–1.5]). *P* value for interaction is 0.6.

mRS to detect small differences in functional recovery between patient groups. Overall, there was no difference in the occurrence of sICH or mortality. Interestingly, if first stent retriever attempt was followed by another stent retriever attempt, sICH rate was 0% regardless of occlusion segment. If aspiration was followed by a stent retriever attempt, sICH remained low; however, this was not zero. Possibly, the vessel wall is more prone to damage caused by the stent retriever after suction is applied.[14]

IC-ICA Occlusion

IC-ICA occlusions are associated with worse outcome because of large clot burden and low collateral filling.[15] In our cohort, these occlusions show the lowest first pass and final recanalization success, regardless of treatment method. Consequently, mortality was the highest in this group and independent outcome rates at 3-month follow-up were relatively low. In previous studies, faster recanalization and higher reperfusion rates were demonstrated by preceding stent retriever thrombectomy with (manual) aspiration to achieve rapid clot burden reduction.[16] This approach seems justified as first pass success rate did not differ between the 2 techniques; however, we did notice higher reperfusion rates if an aspiration attempt was followed by a stent retriever attempt than vice versa. Our finding is supported by a recent study showing superior technical results of aspiration thrombectomy and shorter procedure times in ICA-T occlusions.[17] The combined approach of the techniques may further enhance this recanalization rate.[18]

MCA-M1 Occlusion

Most patients who are eligible for EVT have an occlusion in the M1 segment of the MCA. First pass successful reperfusion was higher in the aspiration group and successful reperfusion at the end of the procedure was achieved more often if first attempt was made with aspiration. Overall complication rate, mortality and clinical outcomes did not differ. If a first pass stent retriever attempt is not successful, it is advisable to switch to aspiration. Second attempt aspiration led to a successful reperfusion in 62% of the patients (vs 32% if treatment method was not altered). On the contrary, in case of failed first aspiration attempt, second attempt with aspiration can be supported because this had a success rate of 72% (vs 46%, if there

Table 2. Procedure Times and Complications in Whole Group and Different Occlusion Segments

	Aspiration		Stent retriever		
	N=624		N=1658		*P* value
Whole group, n (%)					
Time from onset to reperfusion/last contrast bolus (min), median (IQR)	230	(190–288)	260	(204–322)	<0.0001
Duration of procedure (minutes), median (IQR)	50	(35–70)	65	(45–90)	<0.0001
Successful reperfusion at the end of all procedures (eTICI 2B-3), n (%)	450	(72%)	1071	(65%)	0.001
Successful reperfusion first pass (eTICI 2B-3), n (%)	334	(54%)	794	(48%)	0.005
Excellent reperfusion at the end of all procedures (eTICI 2C-3), n (%)	323	(52%)	715	(44%)	<0.0001
Post-EVT eTICI					0.001
0	45	(7%)	160	(10%)	
1	8	(1%)	64	(4%)	
2A	116	(19%)	349	(21%)	
2B	127	(20%)	356	(21%)	
2C	89	(14%)	188	(11%)	
3	234	(38%)	527	(32%)	
SAE any, n (%)	252	(40%)	672	(41%)	1.0
sICH, n (%)	41	(7%)	100	(6%)	0.6
Stroke progression resulting in neurodeterioration or death	57	(9%)	152	(9%)	1.0
New ischemic stroke resulting in neurodeterioration or death	10	(2%)	28	(2%)	1.0
Mortality (3 mo), n (%)	170	(27%)	436	(26%)	0.5
mRS score 0–2 at 3 mo follow-up	245	(39%)	612	(37%)	0.2
	Aspiration		Stent retriever		
	N=134		N=328		
IC-ICA, n (%)					
Time from onset to reperfusion/last contrast bolus (min), median (IQR)	237	(163–293)	265	(210–320)	0.008
Duration of procedure (min), median (IQR)	62	(45–86)	75	(50–99)	0.003
Successful reperfusion at the end of all procedures (eTICI 2B-3), n (%)	98	(73%)	216	(66%)	0.2
Successful reperfusion after first pass (eTICI 2B-3), n (%)	57	(43%)	143	(44%)	0.8
Excellent reperfusion at the end of all procedures (eTICI 2C-3), n (%)	68	(51%)	135	(41%)	0.06
Post EVT eTICI					0.5
0	13	(10%)	37	(11%)	
1	3	(2%)	12	(4%)	
2A	20	(15%)	63	(19%)	
2B	30	(22%)	81	(25%)	
2C	19	(14%)	34	(10%)	
3	49	(37%)	101	(31%)	
SAE any, n (%)	64	(48%)	157	(48%)	1.0
sICH, n (%)	9	(7%)	23	(7%)	1.0
Stroke progression resulting in neurodeterioration or death	16	(12%)	49	(15%)	0.5
New ischemic stroke resulting in neurodeterioration or death	1	(1%)	5	(2%)	0.7
Mortality (3 mo), n (%)	45	(34%)	117	(36%)	0.5
mRS score 0–2 at 3 mo follow-up	48	(36%)	81	(25%)	0.04
	Aspiration		Stent retriever		
	N=346		N=1003		
MCA-M1, n (%)					
Time from onset to reperfusion/last contrast bolus (min), median (IQR)	226	(186–285)	258	(204–322)	<0.0001
Duration of procedure (min), median (IQR)	48	(32–69)	63	(41–89)	<0.0001
Successful reperfusion at the end of procedures (eTICI 2B-3), n (%)	248	(72%)	656	(65%)	0.02

(*Continued*)

Table 2. Continued

	Aspiration		Stent retriever		
	N=624		N=1658		*P* value
Successful reperfusion after first pass (eTICI 2B-3), n (%)	200	(58%)	501	(50%)	0.01
Excellent reperfusion at the end of all procedures (eTICI 2C-3), n (%)	186	(55%)	447	(45%)	0.003
Post-EVT eTICI					0.001
0	19	(5%)	79	(8%)	
1	1	(0.3%)	40	(4%)	
2A	73	(21%)	219	(22%)	
2B	62	(18%)	209	(21%)	
2C	56	(16%)	119	(12%)	
3	130	(38%)	328	(33%)	
SAE any, n (%)	132	(38%)	401	(40%)	0.6
sICH total, n (%)	19	(5%)	57	(6%)	1.0
Stroke progression resulting in neurodeterioration or death	29	(8%)	74	(7%)	0.3
New ischemic stroke resulting in neurodeterioration or death	8	(2%)	15	(1%)	0.3
Mortality (3 mo), n (%)	83	(24%)	246	(25%)	1.0
mRS score 0–2 at 3 mo follow-up	143	(41%)	385	(38%)	0.2
	Aspiration		**Stent retriever**		
	N=144		**N=327**		
MCA-M2, n (%)					
Time from onset to reperfusion/last contrast bolus (minutes), median (IQR)	235	(197–300)	254	(199–326)	0.2
Duration of procedure (minutes), median (IQR)	48	(35–70)	62	(45–85)	<0.0001
Successful reperfusion at the end of all procedures (eTICI 2B-3), n (%)	104	(72%)	199	(61%)	0.04
Successful reperfusion after first pass	77	(53%)	150	(46%)	0.03
Excellent reperfusion at the end of all procedures (eTICI 2C-3), n (%)	69	(48%)	133	(41%)	0.2
Post-EVT eTICI					0.3
0	13	(9%)	44	(13%)	
1	4	(3%)	12	(4%)	
2A	23	(16%)	67	(21%)	
2B	35	(24%)	66	(20%)	
2C	14	(10%)	35	(11%)	
3	55	(38%)	98	(30%)	
SAE any, n (%)	56	(39%)	114	(35%)	0.4
sICH total, n (%)	13	(9%)	20	(6%)	0.3
Stroke progression resulting in neurodeterioration or death	12	(8%)	29	(9%)	1.0
New ischemic stroke resulting in neurodeterioration or death	1	(1%)	8	(2%)	0.3
Mortality (3 mo), n (%)	42	(29%)	73	(22%)	0.06
mRS score 0–2 at 3 mo follow-up	54	(38%)	146	(45%)	0.3

eTICI indicates extended Thrombolysis in Cerebral Infarction; EVT, endovascular treatment; IC-ICA, intracranial part of the carotid artery; IQR, interquartile range; MCA, middle cerebral artery; mRS, modified Rankin Scale; SAE, serious adverse event; and sICH, symptomatic intracranial hemorrhage.

was a switch to stent retriever). However, we did notice a relatively high percentage of sICH if treatment method was not altered after unsuccessful first aspiration attempt.

MCA-M2 Occlusion

For a long time, the EVT of M2 occlusions was debated. As a result of more distal occlusion, area of ischemia is smaller and clinical symptoms less serious, causing the efficacy profile of EVT to differ from more proximal occlusions.[19] Nowadays, these occlusions are eligible for EVT as prior systematic reviews reported positive results in terms of reperfusion and clinical outcome, with acceptable complication rates.[20] Mechanical thrombectomy poses difficulties as the occluded vessel is smaller and the clot more distal in the cerebral circulation, making it more challenging to position the thrombectomy device correctly. Theoretically, there is an increased risk of complications

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Table 3. Overview of Second Attempts

	ICA-IC			MCA-M1			MCA-M2			Total		
	n	% eTICI 2B-3*	% sICH†	n	% eTICI 2B-3*	% sICH†	n	% eTICI 2B-3*	% sICH†	n	% eTICI 2B-3*	% sICH†
Aspiration group‡ (N=177)												
Stent retriever second	44	57%	5%	56	46%	7%	35	57%	9%	135	53%	7%
Aspiration second	5	60%	0%	18	72%	11%	3	33%	0%	26	65%	8%
Stent retriever group‖ (N=484)												
Stent retriever second	33	42%	0%	72	32%	0%	13	23%	0%	118	34%	0%
Aspiration second	75	51%	5%	154	62%	1%	54	61%	6%	283	59%	5%

eTICI indicates extended Thrombolysis in Cerebral Infarction; ICA-IC, intracranial part of the carotid artery; MCA, middle cerebral artery; and sICH, symptomatic intracranial hemorrhage.

*Successful reperfusion (eTICI 2B-3) after second attempt.

†Symptomatic intracranial hemorrhage at the end of all attempts.

‡Second attempt in 16 patients through another method.

‖Second attempt in 83 patients through another method.

because of the smaller lumen and more fragile vessel wall. We noticed higher rates of reperfusion and first pass success in the aspiration group. Similar technical outcomes between the 2 techniques were seen in a study about EVT in M2 occlusions; however, in this study (older), manual aspiration techniques were also analyzed.[21]

If first pass successful reperfusion in the aspiration group was not successful, it is useful to convert to stent retriever and vice versa. Although the difference in mortality in the aspiration and stent retriever groups was not statistically significant, mortality was numerically higher in those treated with first line aspiration. This may partly be explained by a rather high rate of sICH if an unsuccessful aspiration attempt was followed by a stent retriever attempt (9%).

Limitations

We analyzed differences in initial thrombectomy technique per occlusion site. If initial approach failed, the neurointerventionalist may have switched to the other method to achieve successful reperfusion. As a consequence, in both groups, successful reperfusion was achieved by the other method. Thus, this is not a head-to-head comparison between the 2 techniques. We did notice a consistent higher percentage of successful reperfusion in the patients treated with aspiration, regardless of treatment attempt number.

There are a few differences between both groups. Most relevant were the use of general anesthesia, which was more frequently applied in the aspiration group and is associated with worse clinical outcome in the MR CLEAN Registry,[22] and the higher use of balloon guiding in the stent retriever group, which has been shown to improve revascularization success.[23] Furthermore, time from onset to groin was longer in the stent retriever group. We corrected for general anesthesia and time from onset to groin in our analysis.

Thrombectomy techniques have evolved over time. As data acquisition of the MR CLEAN Registry was setup prospectively in 2014, registration of simultaneous aspiration through a large bore aspiration catheter during stent retriever thrombectomy was not accounted for. Unfortunately, we are unable to provide information about the combined use of the techniques. At the start of the MR CLEAN registry stent retrievers were by far the most used devices; in the course of time aspiration catheters were increasingly used in the EVT of ischemic stroke (Figure I in the Data Supplement). We assume that the effect of a learning curve on our results is relatively small: all centers participated in the MR CLEAN trial, where stent retrievers were used in nearly all EVT patients and as a result there was extensive experience with stent retrievers at the beginning of the registry. As the choice of first-line treatment mainly depended on intervention center, selection bias is probably small.

Worth mentioning is the exclusion of one-third of the original cohort, to adequately compare current treatment approaches.

This study reflects the dynamics of EVT in daily clinical practice, where neurointerventionalists may switch thrombectomy method if first pass is not successful. At present, this is the largest study comparing the 2 most commonly used thrombectomy methods. Furthermore, this study may reveal information not displayed in randomized controlled trials because it reflects performance from an interventionalist who is familiar with the technique.

Conclusions

In unselected patients with anterior circulation brain infarcts, we observed equal effects of first-line thrombectomy with stent retriever and aspiration on functional and technical outcome in any of the frequent occlusion segments. Reperfusion rates were higher when aspiration was used as first-line treatment modality and procedure times were shorter, regardless of the occlusion site.

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Supplemental Materials

Tables I and II
Figure I

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