ORIGINAL RESEARCH

An international multicenter retrospective study to survey the landscape of thrombectomy in the treatment of anterior circulation acute ischemic stroke: outcomes with respect to age

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ABSTRACT

Background Thrombectomy is an efficacious treatment for acute ischemic stroke (AIS). However, relatively few studies to date have specifically examined the impact and clinical implications of age on outcomes for thrombectomy in anterior AIS.

Objective To provide a snapshot of patient metrics and outcomes with respect to age following thrombectomy for anterior AIS to supplement the current body of data for predictors of clinical outcomes in a real-world setting.

Methods Data were collected for 20 consecutive patients with AIS treated with thrombectomy at 15 high-volume stroke centers across North America between 2015 and 2016. Patients with anterior occlusions were dichotomized based on whether they were older or younger than 80 years. Ordinal logistic regression analyzed how clinical variables impacted disability using 90-day modified Rankin Scale (mRS) scores.

Results Adequate revascularization (TICI $\geq 2B$) was achieved in 92.3% of patients aged <80 years with an average 1.7 ± 0.1 passes taken with the primary technique and in 88.0% of patients aged ≥ 80 years with an average 1.7 ± 0.2 passes. Despite similar baseline characteristics, mRS scores were significantly higher in older patients postoperatively and at 90 days after intervention. Age was a significant predictor of 90-day mRS across the study population.

Conclusion This analysis affirms age is a significant determinant of 90-day mRS scores following thrombectomy for large vessel anterior AIS. Further investigation into risks faced by elderly patients during thrombectomy may provide actionable information to help refine patient selection and improve outcomes.

elderly, patients ineligible to receive intravenous alteplase, and patients who received treatment more than 300 min after stroke onset.⁶ Benefit for the latter group was confirmed by the DAWN⁷ and DEFUSE-3⁸ trials.

However, it is recognized that results from RCTs sometimes lack generalizability to everyday clinical practice. This phenomenon may relate to aspects of study design such as patient inclusion/exclusion criteria, the selection of participating treatment centers, and individual operator experience. In turn, limited data exist regarding how well results from these trials translate into the real-world setting. Furthermore, relatively few studies to date have specifically examined the impact and clinical implications of age on outcomes for thrombectomy in AIS. Our intention was to provide a detailed international multicenter snapshot of patient metrics before, during, and after thrombectomy for AIS due to anterior occlusion and to evaluate which variables may serve as important determinants for short- and long-term clinical outcomes with respect to age.

METHODS

Data collection

Data from the 20 most recent consecutive AIS patients treated with thrombectomy in 2015–2016 were collected at 15 high-volume stroke centers across North America. These data were obtained as part of the selection process for each center's eligibility for participation in the COMPASS trial, a multicenter prospective RCT comparing a direct aspiration first pass technique (ADAPT) versus stent retrievers in anterior circulation emergent large vessel occlusion, which has been defined as 'an acute vascular occlusion that impairs cerebral perfusion, results in significant clinical deficit, and is accessible for endovascular thrombectomy'.⁹ Approval was obtained from the Institutional Review Boards of the centers in this study.

Clinical outcomes

The clinical variables obtained for each patient included age, sex, vessel occlusion site, imaging

INTRODUCTION

In 2015, five randomized prospective clinical trials (RCTs) demonstrated clear benefit for patients treated with thrombectomy for large vessel occlusive anterior circulation acute ischemic stroke (AIS) over standard medical therapy.^{1–5} Subsequently, the HERMES meta-analysis pooled individual patient data from these trials to determine that a robust therapeutic efficacy for thrombectomy existed in other potential patient populations including the

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modality, intra-arterial (IA) tissue plasminogen activator (tPA) administration, pre-procedure modified Rankin Scale (mRS) score, pre-procedure National Institutes of Health Stroke Scale (NIHSS) score, time from last known well to revascularization, and number of devices and passes to achieve revascularization. Outcomes included the post-procedural mRS and NIHSS, 90-day mRS and NIHSS, final Thrombolysis in Cerebral Infarction (TICI) grade, and post-intervention intracranial hemorrhage (ICH).

Statistical analysis

Patients were dichotomized by age based on whether they were older or younger than 80 years at the time of intervention. Two-sided, two-sample t-tests assessed any differences in continuous quantitative variables, while χ^2 tests were used for categorical variables. Fisher's exact test evaluated any contingency table with an expected count <1 under the null hypothesis of independence. A significance threshold of $p=0.05$ was implemented across all analyses. Univariate and multivariate ordinal logistic regression evaluated how well certain clinical variables predict 90-day mRS scores in patient cohorts and across the entire study population. All statistical analysis was performed using R 3.4.1 (The R Foundation for Statistical Computing, 2016) and all figures were created using Prism 7 (Graphpad, La Jolla, California, USA, 2017).

RESULTS

Cohort demographics and clinical characteristics

A total of 274 patients were included in the study after excluding patients with posterior AIS. 196 patients were aged <80 years (71.5%) while 78 were aged ≥ 80 years (28.5%). Complete revascularization data were available for 257 cases, which

included 182 patients aged <80 years and 75 patients aged ≥ 80 years. Table 1 reports the baseline clinical information of the study population. With the exception of age, the cohorts shared very similar demographics and clinical characteristics overall, particularly with respect to sex, vessel occlusion site, and side of occlusion. Of note, even though both cohorts had similar pre-procedure mRS scores ($p=0.34$), elderly patients had significantly higher baseline NIHSS scores compared with younger patients ($p=0.001$).

Procedural characteristics

Characteristics of the endovascular procedures for both cohorts are shown in table 2. Both cohorts shared similar perioperative and procedural characteristics. Stent retriever was the

Table 1 Demographics and baseline clinical characteristics of the study population

Characteristic	Age <80 (n=196)	Age ≥ 80 (n=78)	P value
Age, years (mean $\pm$ SEM)	63.1 $\pm$ 0.9	85.9 $\pm$ 0.4	<0.001
Female, n (%)	98 (50.3)	48 (61.5)	0.09
Site of vessel occlusion, n (%)			
Internal carotid artery (ICA)	52 (26.5)	23 (29.5)	0.46
L- or T-type ICA	31 (59.6)	12 (52.2)	
Tandem (ICA bifurcation and ICAT or beyond to M1)	15 (28.8)	10 (43.5)	
Cavernous/petrous ICA	3 (5.8)	1 (4.3)	
Anterior cerebral artery	3 (5.8)	0 (0)	
Middle cerebral artery (MCA)	144 (73.5)	55 (70.5)	0.77
First segment	104 (72.2)	37 (67.3)	
Second segment	13 (9.0)	4 (7.3)	
First/second segment bifurcation	25 (17.4)	13 (23.6)	
Third/fourth segment	2 (1.4)	1 (1.8)	
Side of occlusion, n (%)	n=190	n=76	0.41
Right	82 (43.2)	37 (48.7)	
Left	108 (56.8)	39 (51.3)	
Baseline metrics (mean $\pm$ SEM)			
Pre-procedure NIHSS score	15.1 $\pm$ 0.5	18.4 $\pm$ 0.7	0.001
Pre-procedure mRS score	1.0 $\pm$ 0.2	1.4 $\pm$ 0.3	0.34

Threshold for statistical significance was set at $p<0.05$.

mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale.

Table 2 Characteristics of imaging and endovascular procedures

Characteristic	Age <80	Age ≥ 80	P value
Day of the week, n (%)	n=180	n=74	0.16
Monday	29 (16.1)	11 (14.9)	
Tuesday	28 (15.6)	6 (8.1)	
Wednesday	30 (16.7)	20 (27.0)	
Thursday	24 (13.3)	12 (16.2)	
Friday	26 (14.4)	15 (20.2)	
Saturday	21 (11.7)	5 (6.8)	
Sunday	22 (12.2)	5 (6.8)	
Time of day, n (%)	n=173	n=68	0.83
Between 06:00–18:00	112 (64.7)	43 (63.2)	
Outside 06:00–18:00	61 (35.3)	25 (36.8)	
Occurring on weekend, n (%)	43 (23.9)	10 (13.5)	0.07
Imaging modalities used, n (%)	n=196	n=78	0.68
CT	130 (66.3)	57 (73.1)	
CTA	121 (61.7)	52 (66.7)	
CTP	59 (30.1)	19 (24.4)	
MRA	2 (1.0)	0 (0)	
MRI	1 (0.5)	0 (0)	
Received IA tPA, n (%)	104 (53.6)	43 (55.1)	0.82
Primary technique used, n (%)	n=196	n=78	0.91
Stent retriever	83 (42.3)	38 (48.7)	
Direct aspiration (ADAPT)	79 (40.3)	28 (35.9)	
Penumbra with separator	26 (13.3)	9 (11.5)	
IA tPA	2 (1.0)	1 (1.3)	
Other	6 (3.1)	2 (2.6)	
Procedural times, min (mean $\pm$ SEM)			
Stroke onset to hospital arrival	205.2 $\pm$ 17.1	164.1 $\pm$ 19.9	0.17
Hospital arrival to first imaging	63.1 $\pm$ 10.6	50.6 $\pm$ 19.6	0.54
Stroke onset to first imaging	255.1 $\pm$ 22.7	193.9 $\pm$ 26.0	0.13
Hospital arrival to groin puncture	144.2 $\pm$ 13.5	140.6 $\pm$ 23.7	0.89
Stroke onset to IA tPA	141.5 $\pm$ 9.7	130.4 $\pm$ 21.5	0.59
First imaging to groin puncture	117.8 $\pm$ 13.4	100.1 $\pm$ 12.8	0.43
Stroke onset to groin puncture	318.3 $\pm$ 18.3	275.5 $\pm$ 22.0	0.19
Groin puncture to revascularization	47.0 $\pm$ 3.3	49.9 $\pm$ 4.7	0.64
Stroke onset to revascularization	356.6 $\pm$ 18.4	299.0 $\pm$ 18.6	0.08

Threshold for statistical significance was set at $p<0.05$.

CT, CT tomography; CTA, CT angiography; CTP, CT perfusion; IA, intra-arterial; MRA, magnetic resonance angiography; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; tPA, tissue plasminogen activator.

Table 3 Characteristics of clinical outcomes following thrombectomy

Characteristic	Age <80	Age ≥80	P Value
Revascularization rates	n=182	n=75	
Adequate revascularization with primary technique alone (TICI ≥2B), n (%)	137 (75.3)	56 (74.7)	0.92
Number of passes with primary technique to revascularize (mean±SEM)	1.7±0.1	1.7±0.2	0.94
Adequate revascularization after all procedures (TICI ≥2B), n (%)	168 (92.3)	66 (88.0)	0.27
Final TICI score after all procedures, n (%)			
0	1 (0.5)	0 (0)	0.26
1	1 (0.5)	2 (2.7)	
2A	12 (6.6)	7 (9.3)	
2B	74 (40.7)	25 (33.3)	
2C	17 (9.3)	3 (4.0)	
3	77 (42.4)	38 (50.7)	
Outcome metrics (mean±SEM)			
Immediate post-procedure mRS score	2.7±0.2	3.7±0.3	0.002
90-Day mRS score	2.5±0.2	4.2±0.3	<0.001
Immediate post-procedure NIHSS score	8.2±0.7	12.7±1.4	0.003
90-Day NIHSS score	4.4±1.2	18.1±5.8	0.001
Post-intervention intracranial hemorrhage, n (% of total cases)	26 (13.5)	9 (11.8)	0.72
Procedure-related adverse events, n (% of total cases)	9 (4.6)	0 (0)	0.07

Threshold for statistical significance was set at $p<0.05$.

mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; TICI, Thrombolysis in Cerebral Infarction; tPA, tissue plasminogen activator.

most common primary technique in both cohorts, followed by ADAPT. A similar proportion of patients in both cohorts received IA tPA on hospital arrival. Mean procedural times did not differ significantly by age, including time from stroke onset to hospital arrival, time from arrival to revascularization, and time from onset to revascularization. Of note, the median time from stroke onset to revascularization was 249 min (IQR 162–341), which was on a par with the value reported in the HERMES study (median 285; IQR 210–362).⁶

Procedural outcomes

Table 3 reports the collected metrics of short- and long-term clinical outcome following thrombectomy in both patient cohorts by age. Adequate revascularization (defined as final TICI score ≥2B) was achieved in 234 patients after all procedures (91.1%), with similar rates achieved in both cohorts ($p=0.27$). Both groups shared similar final TICI score distributions ($p=0.26$). Similar rates of revascularization and number of passes to revascularize with the primary technique were also observed in both cohorts. In contrast to the relatively similar revascularization metrics shared by both groups, older patients had significantly worse outcome metrics than younger patients, including immediate postoperative NIHSS ($p=0.003$), immediate postoperative mRS ($p=0.002$), 90-day NIHSS ($p=0.001$), and 90-day mRS ($p<0.001$) (figure 1).

Analysis for predictors of functional independence in the study population

Univariate ordinal logistic regression models were built to analyze the relationships between various peri-procedural metrics and 90-day mRS scores in the pooled total study population (table 4). This analysis revealed that age ($p<0.001$), post-intervention ICH ($p=0.001$), passes with the primary technique ($p=0.03$), final TICI ($p=0.02$), pre-procedure mRS ($p=0.002$), pre-procedure NIHSS ($p<0.001$), post-procedure

mRS ($p<0.001$), and post-procedure NIHSS ($p<0.001$) were significant univariate predictors of 90-day mRS. Interestingly, the number of hours from stroke onset to revascularization did not significantly impact the 90-day mRS score ($p=0.32$).

Multivariate ordinal logistic regression models were built using variables that were significant at the univariate level (table 4). In these models, only age ($p=0.04$) remained a significant predictor of 90-day mRS score, while final TICI score ($p=0.48$), post-intervention ICH ($p=0.06$), and passes with primary technique ($p=0.35$) did not. Post-intervention mRS and NIHSS scores were omitted from multivariate regression models because they were covariate with 90-day mRS scores.

Cohort analysis for outcome predictors by age

To further explore how certain clinical variables impact outcomes according to age, ordinal logistic regression models were constructed for both cohorts. Our analysis revealed that post-intervention ICH (age <80: $p=0.002$; age ≥80: $p=0.02$) was a significant predictor of 90-day mRS in both cohorts (table 5). Interestingly, the number of passes with the primary technique ($p=0.03$), pre-procedure mRS ($p=0.003$), pre-procedure NIHSS ($p=0.003$), and hospital CTP imaging ($p=0.05$) were only significant predictors of 90-day outcomes for younger patients. Time from stroke onset to revascularization, final TICI, and IA tPA were not significant predictors of 90-day mRS regardless of age.

DISCUSSION

Thrombectomy is highly effective for anterior large vessel occlusion. Several studies have demonstrated the efficacy of thrombectomy in patients outside the criteria used for admission in the 2015 RCTs.^{10 11} Despite this, there are limited international multicenter data outlining the real-world outcomes from thrombectomy. Our dataset represents a collective effort to examine clinical metrics and outcomes surrounding the treatment of AIS with thrombectomy in a real-life setting. We elected to examine

Figure 1 Distribution of modified Rankin Scale (mRS) scores in patients in the younger (A) and older (B) cohorts before, immediately after, and 90 days after the endovascular procedure. The older cohort shows a significantly greater progression to higher mRS scores over time compared with the younger cohort (C). * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

age as a determinant of outcomes following thrombectomy as relatively few studies to date have focused on analyzing how age impacts thrombectomy outcomes for AIS.

Global analysis of our entire study population suggests that patient age is a significant predictor of functional outcomes following thrombectomy. Older age was associated with significantly increased odds of higher 90-day mRS (table 4). Other pertinent clinical variables, such as post-intervention ICH, passes with the primary device, final TICI, and pre- and post-procedure mRS and NIHSS also appeared to significantly impact 90-day mRS. Interestingly, none of the time variables between stroke onset and revascularization were significant predictors of 90-day mRS in the current study. This is in contrast to prior studies which demonstrated certain time-related variables in stroke management to be predictors of overall outcome.^{12–14} Similarly, while our regression analysis did not show IA tPA to be a predictor of functional outcome, a prior study suggested that thrombectomy in combination with intravenous thrombolysis might improve functional outcomes compared with thrombectomy alone.¹¹

Relatively few studies to date have specifically examined the impact and clinical implications of age on outcomes for thrombectomy in AIS. In 2017, a retrospective cohort study on 219

patients in Italy examined differences in the treatments and outcomes for elderly patients (age >80) following thrombectomy for AIS. While older patients were more likely to receive intravenous thrombolysis and experience shorter revascularization times, they did not differ significantly with respect to successful reperfusion, good clinical outcome, ICH, or mortality compared with younger patients.¹⁵ A similar 2017 single-center study with 80 patients in Japan found that age >80 was not a significant predictor of outcomes following thrombectomy, and that successful revascularization, complete recanalization, and favorable outcomes were more often achieved in elderly patients.¹⁶ Importantly, the HERMES meta-analysis used pooled data to show that thrombectomy provided a clear benefit over standard medical therapy to patients, including older patients aged >80.⁶ The HERMES study also found that, while there was benefit compared with medical management, age was a strong independent predictor of outcomes after thrombectomy. A 2010 review of all Merci thrombectomy cases found a higher rate of stroke-related death in older patients, but no difference in disability at discharge compared with younger patients.¹⁷ In early 2018, a single-center study examined 560 patients including 108 elderly patients aged >80 undergoing an ADAPT procedure for AIS and found that patients aged >80 were significantly less likely to achieve functional independence 90 days after the intervention (defined as mRS ≤ 2).¹⁸ This same study also found that elderly patients were less likely to experience significant increases in good outcomes compared with patients undergoing medical management, and were more likely to experience higher rates of hemorrhage.

In this study we dichotomized patients based on an age cut-off of 80 years as this age is a common exclusion criterion in thrombectomy trials. After dichotomization, the mean age of the older group was 85.9 years and the younger group 63.1 years. Examination of the distributions of mRS scores before and 90 days after the intervention showed clear differences in clinical progression and longer-term outcomes for younger patients (figure 1A) compared with older patients (figure 1B). A significantly greater proportion of patients in the older group progressed to higher mRS scores (figure 1C). In particular, at baseline, 30% of older patients were observed to have an mRS score of ≥ 4 , with this increasing to around 75% at 90 days. In comparison, younger patients had similar baseline mRS scores (24% mRS ≥ 4) which did not progress much further after 90 days (30% mRS ≥ 4). A greater proportion of older patients also progressed to mRS 6 after 90 days (46%) compared with younger patients (20%). A recent retrospective study found similar rates of 90-day mRS ≥ 4 in these age groups, including approximately 65% of patients aged 75–85 and 70% of patients aged 85–95 having a 90-day mRS ≥ 4 .¹⁹ They also reported similar rates of 90-day mRS 6 in older patients, including roughly 35% of patients aged 75–85 and 45% of patients aged 85–95.

It is interesting to note the apparent dissociation observed between final TICI score, times to revascularization, and 90-day mRS, particularly in elderly patients. As previously mentioned, elderly patients experienced a significant decline in their immediate postoperative and 90-day mRS scores compared with younger patients (figure 1). However, in this study, patients in both age cohorts shared similar final TICI distributions, with approximately 90% achieving TICI $\geq 2B$ after all of the techniques were used. Final TICI did not have a significant relationship with 90-day mRS scores in either age cohort (table 5). Similarly, times from stroke onset to revascularization did not differ significantly by age and were comparable to previous values reported in the HERMES study. Our regression analysis also indicated there was

Table 4 Univariate and multivariate regression modeling of patient variables that predict clinical outcome in the total study population

Variable	Univariate		Multivariate	
	OR (95% CI)	P value	OR (95% CI)	P value
Age	1.05 (1.02 to 1.07)	<0.001	1.03 (1.00 to 1.07)	0.04
Gender (male)	0.67 (0.37 to 1.22)	0.19	–	–
Onset to arrival	0.98 (0.90 to 1.07)	0.63	–	–
Onset to imaging	0.98 (0.91 to 1.04)	0.45	–	–
Arrival to imaging	0.99 (0.85 to 1.13)	0.83	–	–
Imaging to GP	0.86 (0.69 to 1.09)	0.21	–	–
Onset to tPA	0.74 (0.51 to 1.07)	0.11	–	–
Onset to GP	0.96 (0.89 to 1.04)	0.34	–	–
GP to revascularization	1.39 (0.89 to 2.53)	0.21	–	–
Onset to revascularization	0.98 (0.89 to 1.07)	0.32	–	–
CT	1.18 (0.64 to 2.18)	0.60	–	–
CTA	0.85 (0.46 to 1.56)	0.60	–	–
CTP	0.58 (0.31 to 1.09)	0.09	–	–
MRA	0.41 (0.02 to 10.75)	0.54	–	–
Pre-procedure mRS	1.40 (1.14 to 1.74)	0.002	1.25 (0.97 to 1.62)	0.09
Pre-procedure NIHSS	1.10 (1.05 to 1.16)	<0.001	1.03 (0.95 to 1.10)	0.05
IA tPA	0.76 (0.42 to 1.36)	0.36	–	–
Passes with primary technique	1.27 (1.03 to 1.59)	0.03	1.17 (0.85 to 1.65)	0.35
Final TICl score	0.70 (0.51 to 0.94)	0.02	0.86 (0.55 to 1.32)	0.48
Post-intervention ICH	4.13 (1.77 to 10.14)	0.001	4.49 (0.99 to 25.55)	0.06
Post-procedure mRS	3.36 (2.57 to 4.52)	<0.001	–	–
Post-procedure NIHSS	1.25 (1.18 to 1.33)	<0.001	–	–

Threshold for statistical significance was set at $p < 0.05$.

CTA, CT angiography; CTP, CT perfusion; GP, groin puncture; ICH, intracranial hemorrhage; MRA, MR angiography; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; TICl, Thrombolysis in Cerebral Infarction; tPA, tissue plasminogen activator.

no significant relationship between times from stroke onset to revascularization and 90-day mRS in either age group (table 5). Despite the somewhat surprising nature of these findings, our results agree with those of a previous study which examined risk factors for thrombectomy in octogenarians.¹⁹ That

retrospective study reported that patients above and below age 80 shared similar final TICl scores, times from stroke onset to groin puncture, and times from groin puncture to recanalization, despite significantly worse 90-day mRS scores in patients aged ≥ 80 years.¹⁹ In addition, their multivariate regression models

Table 5 Regression models comparing the different predictors of clinical outcome by patient age

Variable	Age <80		Age ≥ 80	
	OR (95% CI)	P value	OR (95% CI)	P value
Age	1.03 (1.00 to 1.06)	0.06	1.04 (0.85 to 1.28)	0.68
Gender (male)	0.67 (0.33 to 1.38)	0.28	0.66 (0.19 to 2.22)	0.49
Onset to revascularization	1.02 (0.92 to 1.13)	0.75	0.93 (0.72 to 1.20)	0.54
CT	1.05 (0.50 to 2.20)	0.90	1.08 (0.30 to 3.75)	0.91
CTA	0.94 (0.45 to 1.96)	0.88	0.33 (0.09 to 1.17)	0.10
CTP	0.45 (0.20 to 0.98)	0.05	0.99 (0.27 to 3.74)	0.99
Pre-procedure mRS	1.49 (1.15 to 1.96)	0.003	1.19 (0.82 to 1.79)	0.36
Pre-procedure NIHSS	1.09 (1.03 to 1.16)	0.003	1.06 (0.97 to 1.18)	0.24
IA tPA	0.71 (0.35 to 1.16)	0.34	0.54 (0.16 to 1.72)	0.30
Passes with primary technique	1.32 (1.04 to 1.70)	0.03	1.71 (0.95 to 4.16)	0.18
Final TICl score	0.69 (0.46 to 1.01)	0.06	0.73 (0.44 to 1.20)	0.22
Post-intervention ICH	5.00 (1.87 to 14.02)	0.002	4.33 (1.30 to 17.21)	0.02

Threshold for statistical significance was set at $p < 0.05$.

CTA, CT angiography; CTP, CT perfusion; GP, groin puncture; ICH, intracranial hemorrhage; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; TICl, Thrombolysis in Cerebral Infarction; tPA, tissue plasminogen activator.

suggested that final TIC1 score did not impact 90-day mRS in patients aged ≥ 80 but did in patients aged < 80 years. This trend is also notable in our analyses. These findings lead to the conclusion that age, not lower recanalization, accounted for the discrepancy in 90-day mRS outcomes.

A primary intention of this study was to examine which peri-procedural variables may impact outcomes for older patients compared with younger patients. Ordinal logistic regression analysis by age cohort revealed that post-intervention ICH significantly increased the odds of higher 90-day mRS in both older and younger patients. Post-procedure NIHSS was predictive of 90-day mRS for both younger and older patients, while the pre-procedure mRS and NIHSS scores were significant predictors of 90-day mRS only for the younger cohort. In addition, the number of passes with the primary device was only a predictor of 90-day mRS for younger patients. In our dataset, neither final TIC1 score, IA tPA administration, nor the time from stroke onset to revascularization were significant predictors of outcome for older or younger patients.

These findings suggest that a greater number of peri-procedural variables might serve as negative predictors of clinical outcome for younger patients and might be a function of the inherent mRS score distributions in each cohort. Although their 90-day mRS scores were generally better than those of older patients, younger patients also started out with better postoperative mRS scores and therefore only needed to progress to mid-range mRS scores at 90 days to show a significant decline in mRS score. Older patients, on the other hand, generally started out with higher mRS scores postoperatively, which potentially may have left them with less statistically significant negative predictive variables but a worse profile of clinical outcomes at 90 days.

Given an ageing population and an increased prevalence of AIS with age,^{20 21} it is important to discuss the clinical implications and utility of this type of study. Perhaps most importantly, this study suggests the importance of improving risk prediction algorithms with respect to candidate selection for thrombectomy procedures. Furthermore, our findings underscore the importance of improving diagnostic criteria for futility selection in thrombectomy, particularly with regard to findings from various imaging modalities. It is crucial to understand which patient characteristics are associated with poor long-term outcomes following thrombectomy and to determine alternative treatment algorithms that optimize outcomes for these patient subgroups. This can potentially provide large dividends in terms of cost savings and, more importantly, in human lives.

Finally, it is important to acknowledge the limitations of this study. First, this was a retrospective study, the design of which makes it difficult to assess temporal relationships between variables and introduces the potential for selection bias to exist. In addition, because this was a multicenter study, cases may be subject to certain geographic, institution, and provider-level differences that can be difficult to control for, but do reflect the complex nature of stroke management as it applies in the 'real-world'. Further, it was challenging to obtain complete data for each patient in this study. As such, analysis was limited to patients with a complete profile. Relative to large prospective studies, this study included a relatively small sample size, meaning that analyses may have lacked the power needed to detect statistical significance for variables with smaller effect sizes. Finally, due to the nature of this study, initial ASPECT scores for characterizing initial stroke burden on imaging were not available for analysis.

CONCLUSIONS

Our results from this real-life multicenter study support findings reported in the HERMES meta-analysis and other recent retrospective analyses. Age may have a significant negative impact on 90-day mRS following thrombectomy for AIS. Our results also suggest time to revascularization and final TIC1 are not predictors of worse 90-day outcomes, particularly in elderly patients. We believe the findings from this study warrant further investigation into the critical role that age might play in the long-term outcomes following thrombectomy for anterior AIS. These findings also support the continued development of inclusion and exclusion criteria for these cases to maximize patient benefit and safety and avoid futile reperfusion. Future studies should focus on addressing the risks, complications, and outcomes associated with age following thrombectomy, as these findings might carry profound clinical implications in the management of older patients at stroke centers across North America.

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