THE MEDICAL BULLETIN OF
SISLI ETFAL HOSPITAL

DOI: 10.14744/SEMB.2024.08364
Med Bull Sisli Etfal Hosp 2024;58(4):422–429

Original Research

Outcome of Mechanical Thrombectomy in Patients Older Than 85 Years: A Single Center Experience

Arsida Bajrami,[1] Songul Senadim,[1] Sena Aksoy,[1] Demet Funda Bas,[1] Serdar Geyik[2]

[1]Department of Neurology, Istanbul Aydin University Faculty of Medicine, Istanbul, Türkiye
[2]Department of Radiology, Istanbul Aydin University Faculty of Medicine, Istanbul, Türkiye

Abstract

Objectives: Mechanical thrombectomy (MT) has revolutionized the treatment of acute ischemic stroke (AIS). Still, the efficacy and safety in patients older than 85 years of age are not conclusive by the present randomized controlled trials' data (RCT). Aging is a multifactorial process and the impact of MT on this specific population needs to be further analyzed.

Methods: We retrospectively reviewed 169 patients, ≥85 years old who presented with AIS and underwent MT between 2018 and 2023. Perfusion-weighted imaging (PWI) and software data were also analyzed. Good functional outcome was defined as modified Rankin scale (mRS) ≤2 and assessed at 30 and 90-day follow-ups. Feasibility and safety assessments included First Pass Effect (FPE); hemorrhagic transformation (HT) evaluated according to European Cooperative Acute Stroke Study radiological classification.

Results: Patients were subdivided into two groups (85-90 and >90 years old). A total of 107 (66%) patients had baseline PWI software on onset and median ADC value of 24.19±32.70. Anterior circulation comprised 14.3% (n=24) of the patients; 19.6% (n=33) had middle cerebral artery (MCA) M2, 1.8% (n=3) MCA M3 and 1.8% (n=3) anterior cerebral artery occlusion. Posterior circulation only comprised basilar artery occlusions (n=18). The 3-month mRS of 0-2 was 27% and mRS of 6 was 23.1%. Overall HT was found in 29.2% (n=49) of the patients, but HT1 constituted the highest ratio (70.2%; n=33).

Conclusion: Sub-analysis of several RCTs considered age as a limiting factor for MT in elderly patients. We suggest MT should be considered safe in well-selected candidates older than 85 years.

Keywords: Acute ischemic stroke, elderly patients, mechanical thrombectomy

Please cite this article as "Bajrami A, Senadim S, Aksoy S, Bas DF, Geyik S. Outcome of Mechanical Thrombectomy in Patients Older Than 85 Years: A Single Center Experience. Med Bull Sisli Etfal Hosp 2024;58(4):422–429".

Although Türkiye is known for its relatively young population, recently the elderly proportion has also expanded. Overall life expectancy has increased at all ages and it is expected that also acute ischemic stroke (AIS) frequency will be higher.[1]

Endovascular treatment (EVT) has revolutionized the concept of AIS treatment leading to a better outcome. So far, the proportion of elderly patients (≥85 years) in the present randomized trials of mechanical thrombectomy (MT) in AIS due to large vessel occlusion (LVO) is very low making inconclusive the efficacy and safety results. The Highly Effective Reperfusion evaluated in Multiple Endovascular Stroke Trial (HERMES) study sub-analysis showed the benefit of thrombectomy in patients over 80 years old although the number of those patients was relatively low.[2] Therefore, AIS treatment outcomes in this specific population should be further analyzed. The impact of race and socioeconomic factors over aging raises the question of whether treatment

Address for correspondence: Arsida Bajrami, MD. Department of Neurology, Istanbul Aydin University Faculty of Medicine, Istanbul, Türkiye
Phone: +90 506 059 77 01 **E-mail:** arsidabajrami@gmail.com

Submitted Date: September 11, 2024 **Revised Date:** October 13, 2024 **Accepted Date:** October 17, 2024 **Available Online Date:** December 24, 2024

of these patients differs between countries. Recently published studies showed controversial results regarding the benefit of EVT in elderly patients.[3-5] Multicenter and most importantly multi-national studies are warranted to clarify the impact of MT over this specific population. The limits of MT indication are being expanded in terms of anatomical location as per basilary occlusion[6,7] and infarct core as per large cores.[8] Applying these expanded indications to the elderly population may also lead to variable outcomes.

This study analyzes MT outcome in patients presenting with AIS and LVO, including posterior system occlusion and large core patients, in a Turkish population older than 85 years of age.

Methods

Patients Selection and Data Collection

We retrospectively analyzed the data obtained from the stroke registry of MT performed in our center between November 2018 and November 2023. Patients 85 years and older presenting with AIS that received MT irrespective from the time of onset were enrolled. Those admitted within 4.5 h of onset were pretreated with intravenous tissue plasminogen activator (IV-tPA) if eligible (rt-PA, Actilyse) based on the site doctors' decision. Database was reviewed for demographics, preprocedural modified Rankin scale (mRS), imaging and procedural variables. Risk factors and comorbidities included atrial fibrillation (AF), hypertension (HT), dyslipidemia, smoking, coronary artery disease (CAD), presence of dementia, history of stroke and diabetes (DM). Onset and 24th hour National Institutes of Health Stroke Scale (NIHSS) scores, 1st month and 3rd month modified Rankin scale (mRS) were recorded. Only patients with a mRS score ≥3 (neurologic or non-neurologic related) were excluded from the analysis. Time metrics including onset-to-door, door-to-femoral puncture and femoral puncture to recanalization were also recorded.

Baseline characteristics, as well as radiological and clinical outcomes of patients were analyzed and compared between the two subgroups (patients 85-90 and >90 years old). The study was approved by the Istanbul Aydin University Ethics Committee (63/2024; 17.07.2024). Patients' data was recorded and analyzed in accordance with the Declaration of Helsinki.

Imaging Data Collection

The imaging used on onset consisted of two protocols. Magnetic Resonance (MR)-based protocol included Diffusion-weighted/Perfusion-weighted (DW/PW) imaging in addition or not to vascular imaging based on onsite doctors' decision. Computer Tomography (CT)-based protocol included CT/CTP in addition or not to vascular imaging. Patients' onset and 24th hour post-procedure imaging findings were analyzed. Onset and 24th hour Alberta Stroke Programme early CT (ASPECT) scores were recorded for each patient. Perfusion software data were analyzed and Apparent Diffusion Coefficient (ADC) volume, mismatch ratio and volume were recorded. Software analysis was performed using RAPID (Ischemia View, Menlo Park, CA) and Olea (Olea Medical, La Ciotat, France) software.

Revascularization Procedures Data Collection

All procedures were performed in a biplane angiography suite. Anterior and posterior occlusion sites were analyzed and anatomically classified as follows: internal carotid artery (ICA), middle cerebral artery (MCA M1, M2, M3), posterior cerebral artery (PCA P1, P2) and anterior cerebral artery (ACA A1, A2) occlusions. Access route was also recorded and subclassified as femoral, radial, direct carotid puncture or more than one route. Thrombolysis in Cerebral Infarction (eTICI) scale was used to assess recanalization rate. Procedure-related characteristics defined as total number of passes, first pass technique (ADAPT as single aspiration vs. Solumbra as stent retriever combined with aspiration), first pass effect (FPE), final successful recanalization and fragmentation were also recorded. TICI ≥ 2b in the final angiography run was defined as successful recanalization. The presence of tandem occlusion and immediate stenting during procedure was also recorded.

Clinical Outcomes

The mRS score was used as the primary clinical outcome and was subcategorized into good outcome (mRS score 0–2) and poor outcome (mRS score 3–6). Both 30-day and 90-day mRS scores were recorded. Also 24th hour NIHSS was recorded for all patients. In case of a lack of in-hospital visits, telephone calls were performed by stroke neurologists. Hemorrhagic transformation (HT) and clinical impact were evaluated and recorded using European Cooperative Acute Stroke Study (ECASS) radiological classification of hemorrhagic infarcts (HI1 and HI2), parenchymal hematomas (PH1 and PH2) and subarachnoid hemorrhage.[9]

Statistical Analysis

SPSS 27 (Statistical Package for the Social Sciences; Chicago, IL: IBM Corp.) program was used for statistical analysis. Descriptive statistics and univariate comparisons were performed. Mann-Whitney U tests were conducted for unpaired comparisons and Student-t test for paired comparisons. All tests were two-sided and an α value <0.05 was considered significant. The suitability of quantitative data for normal distribution was tested using the Shapiro-Wilk

test and graphical analysis. Student-t test was used to compare normally distributed quantitative variables between two groups, and Mann-Whitney U test was used to compare non-normally distributed quantitative variables between two groups. T test was used for intragroup comparisons of normally distributed quantitative variables. Pearson chi-square test, Fisher's exact test and Fisher-Freeman-Halton test were used to compare qualitative data. Statistical significance was accepted as $p<0.05$.

Results

Baseline Data

The data of a total of 169 patients 85 years or older, who underwent MT in our center, between November 2018 and November 2023 and fulfilled the inclusion criteria were analyzed. Patients' mean age was 88.09 (SD 3.11). Fifty-one patients (30.2%) were male. The data was dichotomized into two subgroups according to patients' age; 74% (n=125) of the patients aged 85-90 and 26% (n=44) older than 90 years of age (Fig. 1). The mean baseline NIHSS score was 16.99 (SD 4.98), 24th hour NIHSS and 1st month NIHSS scores were 10.53±7.26 and 6.26±5.50, respectively. There was no significant difference between groups in terms of onset and 24th hour NIHSS ($p>0.005$). The majority of the patients' pre-mRS was 1 (43.8%) with only 6.5% of the patients with pre-mRS score of 3.

In terms of baseline risk factors and comorbidities, AF (74% [n=125]) and HT (76.9% [n=130]) were the most frequent. Dementia was present in 19.5% (n=33) of the patients. Ipsilateral atherosclerotic stenosis and active smoking were less frequent (14.8% and 10.1%) overall. Although the mean onset-to-door time was 286.48±206.13 min, treatment with IV tPA was provided to only 7.1% of all patients.

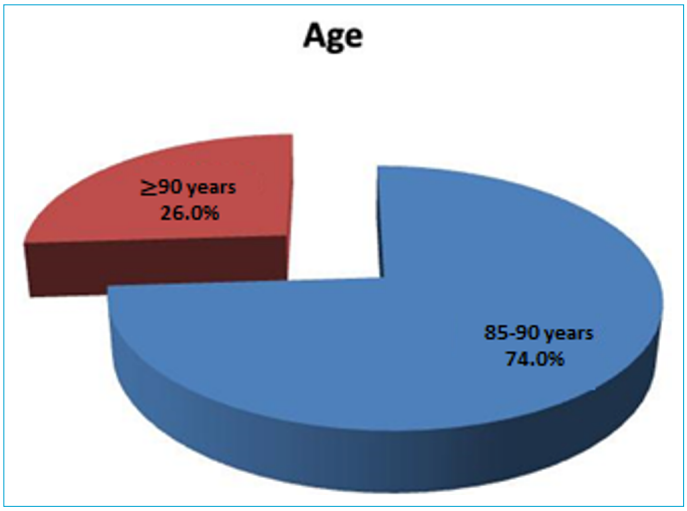

Figure 1. Distribution according to the age of the patients.

The decision was based on the short door-to-puncture time of mean 41.25±16.54 minutes. The mean femoral puncture to recanalization time was 27.50±21.10 minutes. Femoral puncture-recanalization time did not statistically differ between two subgroups ($p>0.005$).

The median CT ASPECT on onset was 8.51±2.04 and the median DW ASPECT on onset was 8.50±1.06. The median 24th hour CT and DW ASPECT scores were 7.33±2.40 and 7.75±1.7, respectively. A total of 107 (66%) patients had baseline PW imaging software on onset. The median ADC value on PW imaging software data was 24.19±32.70. The median mismatch ratio and volume values were 8.92±17.54 and 92.89±123.12, respectively. Accordingly, most of the patients consisted of low ADC values with high mismatch ratio and volume, indicating a good profile. Table 1 and 2 demonstrate the baseline characteristics.

Procedural Data

Angiographic findings confirmed 56.5% of patients had MCA M1 occlusion. In terms of anterior circulation, 14.3% (n=24) of the patients had ICA, 19.6% (n=33) MCA M2, 1.8% (n=3) MCA M3 and 1.8% (n=3) ACA occlusion. Posterior cir-

Table 1. Baseline characteristics of the patients

	n (%)
Age	
85-90	125 (74.0)
≥90	44 (26.0)
Gender	
Female	118 (69.8)
Pre-mRS	
0	46 (27.2)
1	74 (43.8)
2	38 (22.5)
3	11 (6.5)
AF	125 (74.0)
HT	130 (76.9)
DM	47 (27.8)
Dementia	33 (19.5)
CAD	57 (33.7)
Dyslipidemia	50 (29.6)
Stroke before onset event	28 (16.6)
Atherosclerotic Stenosis	25 (14.8)
Smoking	
Ex- smoker	89 (52.7)
Active smoker	17 (10.1)
Non-smoker	63 (37.3)
IV-tPA	12 (7.1)

*mRS: modified Rankin score; *AF: atrial fibrillation; *HT: hypertension; *DM: diabetes mellitus; *CAD: coronary artery disease; *IV-tPA: intravenous tissue plasminogen activator

Table 2. Baseline characteristics of the patients

	Average±SD Median (Min-Max)
Onset NIHSS	16.99±4.98 18 (3-26)
24th hour NIHSS	10.53±7.26 10 (0-32)
1st month NIHSS	6.26±5.50 4 (0-22)
Onset-Door (min)	286.48±206.13 245 (30-1440)
Door-Fem. puncture (min)	41.25±16.54 41 (10-110)
Fem. puncture- recanalization (min)	27.50±21.10 22 (0-135)
1st month mRS	3.17±1.63 3 (0-6)
3rd month mRS	3.00±1.92 3 (0-6)
Onset ASPECT CT	8.51±2.04 9 (0-10)
24th hour ASPECT CT	7.33±2.40 8 (0-10)
Onset ASPECT DWI	8.50±1.06 9 (6-10)
24th hour ASPECT DWI	7.75±1.73 8 (0-10)
Onset software PWI	107 (66.0)
ADC	24.19±32.70 9.5 (0-107)
Mismatch Ratio	8.92±17.54 3.35 (0.32-130)
Mismatch Volume	92.89±123.12 68 (-29-1150)

*NIHSS: National Institutes of Health Stroke Scale; *mRS: modified Rankin score; *ASPECT: Alberta Stroke Programme early CT score; *CT: computed tomography; *DW: Diffusion Weighted Imaging; *PWI: Perfusion Weighted Imaging; *ADC: Apparent Diffusion Coefficient.

culation only comprised basiler artery (BA) occlusions with a total of 18 patients (6%).

Femoral route was used for most of the patients (89.3%; n=151). Only one patient's access wasn't successful despite trying both femoral and radial route. Successful access was obtained by direct carotid puncture in only one patient.

Further analysis of procedure data showed that both aspiration and stent retriever (SOLUMBRA) were used as first pass technique in 76.8% (n=129) and only aspiration technique (ADAPT) in 23.2% (n=29) of the patients. The median number of total passes performed was 1.79±1.19. Number of passes did not differ statistically between two subgroups (p>0.005). Fragmentation was seen in 35.5% (n=59) of the patients. Tandem occlusion was observed in 8.9% (n=15) of the patients with immediate stenting performed in 6.5% (n=11) of the patients. No statistical difference was found between two subgroups in terms of fragmentation, occlusion site, presence of tandem and stenting (p>0.005). FPE was achieved in 52% (n=54) of the patients in the 85-90 years old group and 41.1% (n=22) in the >90 years old group. Final successful recanalization was achieved in 94.7% (n=117) and 91% (n=40) in 85 to 90 years and >90 years old group, respectively. No statistical difference was found between two subgroups in terms FPE and final successful recanalization (p>0.005). Recanalization data and procedural characteristics are shown in Table 3, 4 and 5.

Safety and Clinical outcomes

The modified Rankin Scale (mRS) score at 30 and 90 days was used as the primary clinical outcome. The mean 30th day and 90th day mRS was 3.17±1.63 and 3.00±1.92. The percentage of 1st month mRS 0-2 was 42.9%. Overall, 1st month mRS of 6 was 16.7%. The 3-month mRS of 0-2 was 27% and mRS of 6 was 23.1% (Fig. 2). No statistical differ-

Table 3. Procedural characteristics

	85-90 year n (%)	≥90 years n (%)	p
IV-tPA			
Yes	114 (91.2)	43 (97.7)	[a]0.189
No	11 (8.8)	1 (2.3)	
Occlusion Site			
ICA	17 (13.6)	7 (16.3)	[b]0.967
MCA (M1)	72 (57.6)	23 (53.5)	
M2	24 (19.2)	9 (20.9)	
M3	2 (1.6)	1 (2.3)	
BA	8 (6.4)	2 (4.7)	
ACA	2 (1.6)	1 (2.3)	
Fragmentation			
Yes	78 (63.4)	29 (67.4)	[c]0.635
No	45 (36.6)	14 (32.6)	
First Pass Tech			
ADAPT	28 (22.4)	11 (25.6)	[c]0.670
SOLUMBRA	97 (77.6)	32 (74.4)	
Tandem			
Yes	114 (91.2)	39 (90.7)	[a]1.000
No	11 (8.8)	4 (9.3)	
Stent			
Yes	117 (93.6)	40 (93.0)	[a]1.000
No	8 (6.4)	3 (7.0)	

*IV-tPA: Intravenous tissue plasminogen activator; *ICA: Internal Carotid Artery; *MCA: Middle Cerebral Artery; *BA: Basiler Artery; *ACA: Anterior Cerebral Artery; *ADAPT: A Direct Aspiration First Pass Technique.

Table 4. Procedural characteristics

	Nr (%)
Fragmentation	59 (35,5)
Number of passes	1.79±1.19
	1 (1-11)
First Pass Technique	
ADAPT	39 (23.2)
SOLUMBRA	129 (76.8)
Access Route	
Femoral	151 (89.3)
Radial	13 (7.7)
Carotid	1 (0.6)
Femoral + Radial	3 (1.8)
No access	1 (0.6)
Occlusion Site	
Left	71 (44.4)
Occluded Vessel	
Right	89 (55.6)
ICA	24 (14.3)
MCA M1	95 (56.5)
M2	33 (19.6)
M3	3 (1.8)
BA	10 (6.0)
PCA	0 (0.0)
ACA	3 (1.8)

*ADAPT: A Direct Aspiration First Pass Technique; *ICA: Internal Carotid Artery; *MCA: Middle Cerebral Artery; *BA: Basiler Artery; *PCA: Posterior Cerebral Artery; *ACA: Anterior Cerebral Artery.

Table 5. First pass effect and final TICI according to age groups

	Age		
	85-90 years	>90 years	Total
First Pass Effect TICI, n (%)			
TICI 0	21 (16.8)	8 (18.6)	29 (17.3)
TICI 2a	4 (3.2)	2 (4.6)	6 (1.8)
TICI 2b50	20 (16.0)	7 (16.3)	27 (16.1)
TICI 2b67	14 (11.2)	4 (9.3)	18 (9.5)
TICI 2c	19 (15.2)	5 (11.6)	22 (13.1)
TICI 3	46 (36.8)	17 (39.5)	63 (37.5)
ICA T	1 (0.8)	0 (0.0)	1 (0.6)
Final TICI			
0	5 (4.0)	3 (6.8)	8 (4.7)
2a	3 (2.4)	1 (2.3)	4 (2.3)
2b50	5 (4)	4 (9.1)	9 (5.3)
2b67	15 (12)	5 (11.4)	22 (13)
2c	29 (23.2)	5 (11.4)	32 (18.9)
3	68 (54.4)	26 (59.1)	94 (55.6)

*TICI: Thrombolysis in cerebral infarction; *ICA T: Internal Carotis Artery Tip.

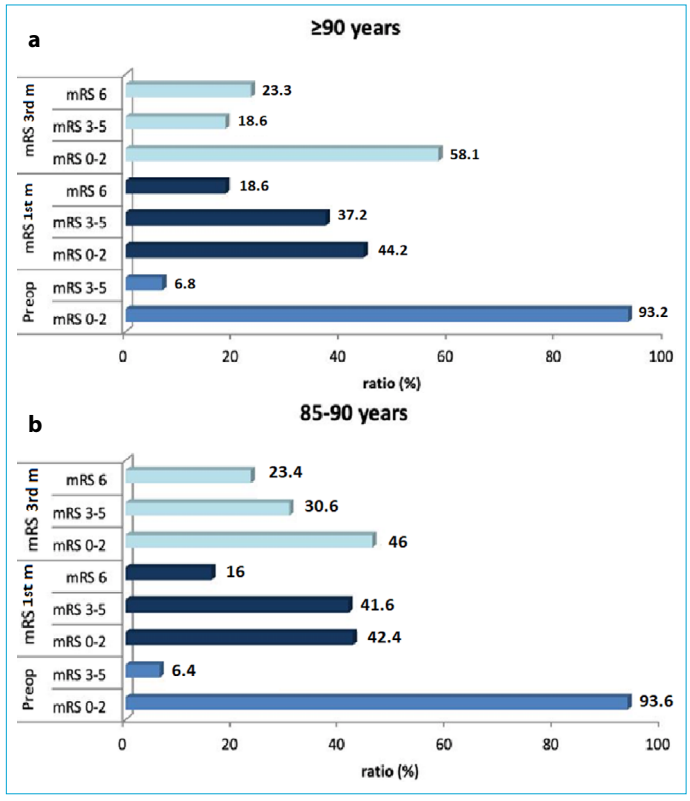

Figure 2. Pre-op, 1st and 3rd month mRS scores and distribution between subgroups. **(a)** 85-90 years of age subgroup, **(b)** ≥90 years of age subgroup.

ence was found between subgroups in terms of both 1st month and 3rd month mRS. Overall HT was found in 29.2% (n=49) of the patients, but HT1 constituted the highest ratio (70.2%; n=33). SAH with no associated neurological deuteriation was the second highest type of HT observed in 26.2% (n=11) of the patients. Presence of HT did not show any statistical difference between two age subgroups (p>0.005) (Table 6).

Discussion

As per today, several studies suggest that age has a bad impact over the rate of good outcome following MT.[3,10-12] HERMES collaboration findings of the meta-analysis suggested a significant beneficial effect of MT in patients aged ≥80. In this collaboration especially patients aged ≥90 years sample size was very low.[3] There might be a difference in terms of the impact of age on MT outcome between age group of 85 to 90 versus patients older than 90. The presence of more comorbidities in this group might affect the ability to recover in general leading to poorer prognosis. The analysis of MT in these specific age group so far has only been made through few reports mostly including small single-center case series with inconsistent conclusions.[5,12,13]

Table 6. The mRS score and HT distribution between sub-groups

	Age		p
	85-90 years	≥90 years	
1st month mRS, n (%)			
0-2	53 (42.4)	19 (44.2)	[c]0.858
3-5	52 (41.6)	16 (37.2)	
6	20 (16.0)	8 (18.6)	
3rd month mRS, n (%)			
0-2	57 (46.0)	25 (58.1)	[c]0.267
3-5	38 (30.6)	8 (18.6)	
6	29 (23.4)	10 (23.3)	
HT, n (%)			
Yes	88 (70.4)	31 (72.1)	[c]0.833
No	37 (29.6)	12 (2.9)	
HT1, n (%)			
Yes	11 (30.6)	3 (27.3)	[a]1.000
No	25 (69.4)	8 (72.7)	
HT2, n (%)			
Yes	26 (89.7)	8 (80.0)	[a]0.587
No	3 (10.3)	2 (20.0)	
PH1, n (%)			
Yes	27 (96.4)	10 (100.0)	[a]1.000
No	1 (3.6)	0 (0.0)	
SAH, n (%)			
Yes	22 (71.0)	9 (81.8)	[a]0.696
No	9 (29.0)	2 (18.2)	

*mRS: modified Rankin score; *HT: hemorrhagic transformation; *PH: parenchymal hematoma; *SAH: subarachnoid hemorrhage.

This retrospective analysis of a large Turkish cohort includes a very homogeneous group of elderly patients 85 years or older treated with MT. Imaging data indicates mostly good-profile patients with optimal pre-stroke conditions. Also, patients' demographic data, risk factors, onset NIHSS and pre-mRS did not differ between subgroups. Although Türkiye is known for relatively young population, the proportion of the elderly increased to 9.9% in 2022 and 7.9% of this elderly population comprises age 85 and older according to the statistics.[14] Still, according to Turkish culture, a large proportion of the elderly people are taken care and co-live with their relatives, generating difficulty in defining independency. Therefore, mRS evaluation pre- and post-procedure should be individualized according to social circumstances, especially in the elderly population. In elderly patients with severe stroke, even post-stroke depression has an impact over the quality of life and compromises the effectivity of rehabilitation.[15] This indicates that evaluation of 3rd month mRS is variable and multi-factorial. Quality of life is found to be similar in the mRS 2 and 3 groups that theoretically represents different functional disability, indicating that the use of mRS 0–3 should be preferred to mRS 0–2.[16] We included also patients with pre-mRS 3 and believe optimized patient selection for MT in this specific group should be multifactorial. Still, majority of the patients included had favorable characteristics; pre-mRS 1 in 43.8% (n=74) and mRS 3 in only 6.5% of the patients. Baseline imaging features also included median ASPECT of 8.51 for both CT and DW group. In addition, 66% of the patients (n=107) had baseline PW imaging software on onset with median ADC value of 24th 19±32.70.

In this study, a good functional outcome (mRS ≤2) was achieved in 49% (82/167) of the patients at 90-day follow-up. Surprisingly, subgroup analysis shows a better functional outcome (mRS ≤2) in the >90 years old group (58%) compared to 85 to 90 years old patients' group (46%). Previous representative MT trials reports very wide range from 30% to 70% of good favorable outcome.[2] Specific analysis about the selection criteria, and most importantly detailed imaging and strict selection criteria have not been reported yet. Our findings support the fact that very good selection may overcome the age limit of benefit for MT.

Better clinical outcomes are shown to be related with the term FPE, defined as achieving mTICI 2c/3 from the first device pass.[16,17] There are several factors that have an impact over FPE, but the direct relationship of age is not well established. A retrospective analysis of 124 nonagenarians treated with MT highlighted that only patient with successful recanalization after the first thrombectomy device pass had an increased rate of good outcome and a reduced 90-day mortality.[18] In this series, FPE was achieved in 52% of cases in the 85–90-year-old group and in 41% of the cases in the >90-year-old group.

The HT ratio was relatively low (29.2%) and HT1 constituted 70% of HT. Still the second highest type of HT observed was SAH with no associated neurological deterioration (26.2%). This might be related with increased tortuosity and atherosclerotic changes in elderly patients. Moreover, presence of HT did not show any statistical difference between two age subgroups. We also report a relatively low iv-tPA ratio compared with other studies (only 7.1% of all patients). The low rate of iv-tPA use was driven by the short door-to-femoral puncture time but may provide an explanation to the low HT rate. The present data is not conclusive whether MT alone is superior to combined iv-tPA and MT regarding functional outcome and hemorrhagic complications in elderly patients.[19] Still there are few data showing that elderly patients may be at higher risk for ICH with thrombolysis.[20] The low rate of tPA and sICH in this cohort also may also be suggestive of an increased risk in bridging therapy especially in elderly patients.

Overall, the clear effect of age and aging differences derived from social circumstances of different countries on MT outcome in elderly patients emphasizes the importance of a better understanding of the underlying causes to improve patients selection, treatment strategy and achieve better outcome.

The retrospective and single-center study design generates certain limitation. Comparison to a younger cohort might also help distinct factors which make a difference in outcome. Nevertheless, this large cohort may help understand the post-MT outcome of elderly patients and especially point out the differences between aging in different countries. Also, being generous and selective in terms of onset imaging modalities favors MT in well-selected patients.

Conclusion

Although studies regarding MT in this specific age group are controversial, decision for treatment based on age only might lead to limited evaluation. Eventually, treatment effect in these group when compared to younger age groups may differ. Large and most importantly multi-national studies including this specific group of patients shall help define factors favoring better outcome. Until then, it is important to analyze patients' onset imaging in addition to pre-mRS and concomitant medical conditions, individually for each case.

Disclosures

Ethics Committee Approval: The study was approved by the Istanbul Aydin University Non-interventional Clinical Research Ethics Committee (date: 17.07.2024, no: 63/2024).

Peer-review: Externally peer-reviewed.

Conflict of Interest: The authors declared that they have no conflict of interest.

Financial Support (Funder's Name): This study was not supported by any funding.

Authorship Contributions: Concept – A.B., S.G.; Design – A.B., S.S.; Supervision – S.G., D.F.B.; Fundings – S.A., A.B.; Data collection &/ or processing – S.A., A.B.; Analysis and/or interpretation – A.B., S.S.; Literature search – S.S.; Writing – A.B.; Critical review – S.G., D.F.B.

Use of AI for Writing Assistance: Artificial intelligence technologies were not used in this study.

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