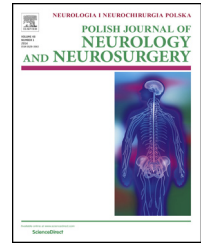


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## Original research article

# Mechanical thrombectomy: Determining the proportion of eligible acute ischemic stroke patients in the cohort of single academic stroke center



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## ABSTRACT

**Background and purpose:** Mechanical thrombectomy (MT) is now well-established treatment method for selected patients with acute ischemic stroke (AIS) and efforts are being made to incorporate it into the systems of stroke care. Our objective is to assess the number of AIS individuals eligible for MT in the cohort of single academic stroke center.

**Methods:** We retrospectively reviewed initial non-invasive vascular imaging data of AIS patients presenting within 5 h of symptom onset for the presence of large vessel occlusion (LVO) over 2-year period (2015–2016). Among subjects confirmed with LVO: time-to-presentation, premorbid functional and on-admission neurological state, site of occlusion and initial imaging data were further assessed. Two sets of criteria based on recent trials and recommendations were used to determine MT eligibility. The onset-to-evaluation time limit was set to 5 h allowing  $\leq 60$  min procedure initiation delay.

**Results:** 895 patients with the final diagnosis of AIS were admitted to our stroke center as the initial treatment facility. 246 (27.5%) presented within 5 h of symptom onset and had non-invasive imaging performed. Among those 102 (41.5%) had causative LVO. The number of  $\leq 5$  h presenting patients eligible for MT was 51 (20.7%) when applying restrictive or 80 (32.5%) with more permissive criteria.

**Conclusion:** Among AIS patients, in whom onset-to-arrival time allowed to initiate the endovascular procedure within 6 h of symptom duration, 21% were eligible for MT treatment according to more and 33% to less restrictive criteria. It accounts for about 6% and 9% of all AIS cases, respectively.

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Abbreviations: AIS, acute ischemic stroke; NIHSS, National Institutes of Health Stroke Scale; mRS, modified Rankin scale; EVT, endovascular treatment; MT, mechanical thrombectomy; LVO, large vessel occlusion; IVT, intravenous thrombolysis; RCTs, randomized controlled trials; ASPECTS, Alberta Stroke Program Early CT Score.

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## 1. Introduction

Large vessel occlusion (LVO), responsible for the significant portion of acute ischemic strokes (AIS) [1], is associated with low rates of recanalization and poor prognosis when treated medically [2]. Since 2015 several randomized clinical trials (RCTs) proving superiority of LVO treatment by mechanical thrombectomy (MT) were published [3]. These data have led to development of European Stroke Organization (ESO) consensus statement [4] and American Heart Association/American Stroke Association (AHA/ASA) guideline [5] that recommend MT as a first-line treatment method in a selected group of patients.

Recently, efforts are being made to implement endovascular AIS treatment into the health care systems worldwide. Developing regional stroke care network based on primary and comprehensive centers, with capability of the latter to perform MT, has been proposed [5]. In practice, organization of the AIS management relies on the predicted demands and cost-effectiveness analyses. Both require estimations of MT eligible patients.

Indifferently, the arrangement of national stroke care system that includes endovascular treatment facilities in Poland is debated. The purpose of our study is to determine the proportion of AIS patients suitable for MT to assist this process.

## 2. Materials and methods

### 2.1. Study population

Between January 2015 and December 2016 928 individuals with the final diagnosis of AIS were admitted to the single stroke center in Rzeszów (Poland) that is offering endovascular treatment [6]. 33 were transfers from other units (5 referred for MT) and were excluded from this study to obtain 895-patient cohort that had the opportunity to undergo entire reperfusion therapy qualification process in our department.

All subjects had initial non-contrast CT imaging and clinical evaluation by a neurologist. When eligible, intravenous thrombolysis (IVT) was administered ( $n = 201$ ; 22.5%). According to in-hospital stroke protocol, every acute stroke patient within 5 h of symptom onset should have CT-angiogram performed during qualification for reperfusion therapy unless contraindications for iodine contrast administration (known allergy or renal failure). 189 (94%) out of 201 IVT-treated group had non-invasive vascular imaging performed. When LVO was confirmed, endovascular treatment (EVT) eligibility was further assessed by the endovascular treatment team (experienced neurologist and neuroradiologist).

For this study, we reviewed all AIS initial non-invasive vascular imaging data from the 2-year period (2015–2016) excluding subjects with onset-to-arrival time  $>5$  h ( $n = 47$ ). 246 (27.5%) individuals were identified in this manner. There was no emergent MR-angiography in the settings of AIS done.

### 2.2. Clinical and imaging data

The selected 246-patient group had their initial non-invasive vascular imaging assessed for the presence of treatable LVO

[causative occlusion of intracranial internal carotid artery (ICA), the first (M1), second (M2) or third (M3) segment of middle cerebral artery (MCA), first (A1) or second (A2) portion of the anterior cerebral artery (ACA), dominant vertebral artery (VA), basilar artery (BA) and first (P1) segment of posterior cerebral artery]. The subjects with confirmed LVO had their records reviewed. Data on onset-to-presentation time, pre-morbid modified Rankin Scale (mRS), National Institutes of Health Stroke Scale (NIHSS) score on admission, site of vessel occlusion and on initial CT imaging were collected.

### 2.3. Eligibility criteria

We applied two sets of criteria derived from MT RCTs that were modified to fit clinical scenario. In both of them onset-to-presentation time was limited to 5 h to allow  $\leq 60$  min of in-hospital delay to initiate endovascular treatment. More restrictive criteria included subjects with MCA M1 and/or intracranial ICA occlusion with pre-morbid mRS  $\leq 2$ , on-admission NIHSS  $\geq 6$  and initial CT ASPECT score of more than 5. The less stringent MT criteria encompassed cases of the broader range of causative LVOs (intracranial ICA, M1, M2 segments of MCA, A1 and A2 portions of ACA, BA and P1 segment of PCA), lower NIHSS threshold ( $\geq 3$ ) and higher pre-morbid disability (mRS  $\leq 3$ ). The tandem occlusion of MCA and ICA was not regarded as MT contraindication in neither group.

### 2.4. Statistical analysis

The analysis was started by checking the normal distribution (Shapiro–Wilk test). Quantitative variables are presented by rate (%). Continuous variables are presented as mean  $\pm$  SD (normal distribution) and as median with interquartile range (skewed distribution).

## 3. Results

In 246 cases onset-to-evaluation time allowed initiation of MT within 6 h of symptom onset and initial non-invasive vascular imaging was available. Among those we found 102 (41.5%) intracranial LVO. The localization of vessel occlusion and basic characteristics of the LVO-group are shown in the [Tables 1 and 2](#), respectively.

According to predefined restrictive MT eligibility criteria, 75 subjects with M1 or terminal ICA closure were identified. Twenty-four of them were subsequently excluded because of: mild neurological deficit (NIHSS score  $<6$ ) in 3, pre-morbid functional dependency (mRS  $>2$ ) or unknown status in 11, extensive early ischemic changes on initial imaging (ASPECTS  $<6$ ) in 4 and there was more than one cause in 6 cases ([Fig. 1](#)). With this approach we found 51 (20.7%) individuals to be eligible for endovascular treatment.

When applying less strict criteria, 97 patients with treatment-qualifying LVO (M1, M2, A1, A2, intracranial ICA, P1, BA) were determined. In this group, four subjects with extensive early ischemic changes on initial imaging (ASPECTS  $<6$ ), 6 with mRS  $>3$  or unknown, 2 with very mild baseline deficit (NIHSS  $<3$ ) and other 5 with more than one exclusion

**Table 1 – The localization of vessel occlusion.**

Location (n = 102)	n (%)
Intracranial ICA	9 (8.8%)
M1	50 (49%)
M2	12 (11.8%)
M3	3 (2.9%)
A1	1 (1%)
A2	1 (1%)
BA	5 (4.9%)
P1	3 (2.9%)
VA	2 (2%)
Tandem ICA + MCA occlusion	16 (15.7%)

Abbreviations: ICA, internal carotid artery; MCA, middle cerebral artery; M1, first segment of middle cerebral artery; M2, second segment of middle cerebral artery; M3, third segment of middle cerebral artery; BA, basilar artery; P1, first segment of posterior cerebral artery; VA, vertebral artery.

**Table 2 – Basic characteristics of the LVO cohort.**

Variable	
Median age (IQR), years	79 (66–85)
Female sex, n (%)	62 (61%)
Median onset-to presentation time (IQR), min	77 (50–134)
Median NIHSS on-admission (IQR), points	15 (10–18)
Median baseline ASPECTSS (IQR), points	9 (8–10)
Intravenous thrombolysis (IVT) treatment, n (%)	77 (76%)

criteria were found. Hence, we identified 80 (32.5%) subjects potentially qualifying for MT with permissive algorithm.

#### 4. Discussion

We found that around 40% of AIS individuals arriving within the EVT time window might have causative LVO. It is now proven that in this group MT is the most effective treatment method [4,5]. Employment of further MT inclusion criteria, however, leads to ruling out up to half of them. Our estimations show that, depending on qualification algorithm used, 21 or 33% are eventually eligible for thrombectomy. These results are consistent with the 26% given in the French regional registry study [7]. The other single-center analysis, assessing eligibility to each of seven recent EVT RCTs demonstrated rates widely ranging from 3 (THRACE [8]) to 53% (MR CLEAN [9]) [10]. The higher values provided are probably closer to real-world clinical practice, as the inclusion criteria tend to be more restrictive in most of the trials.

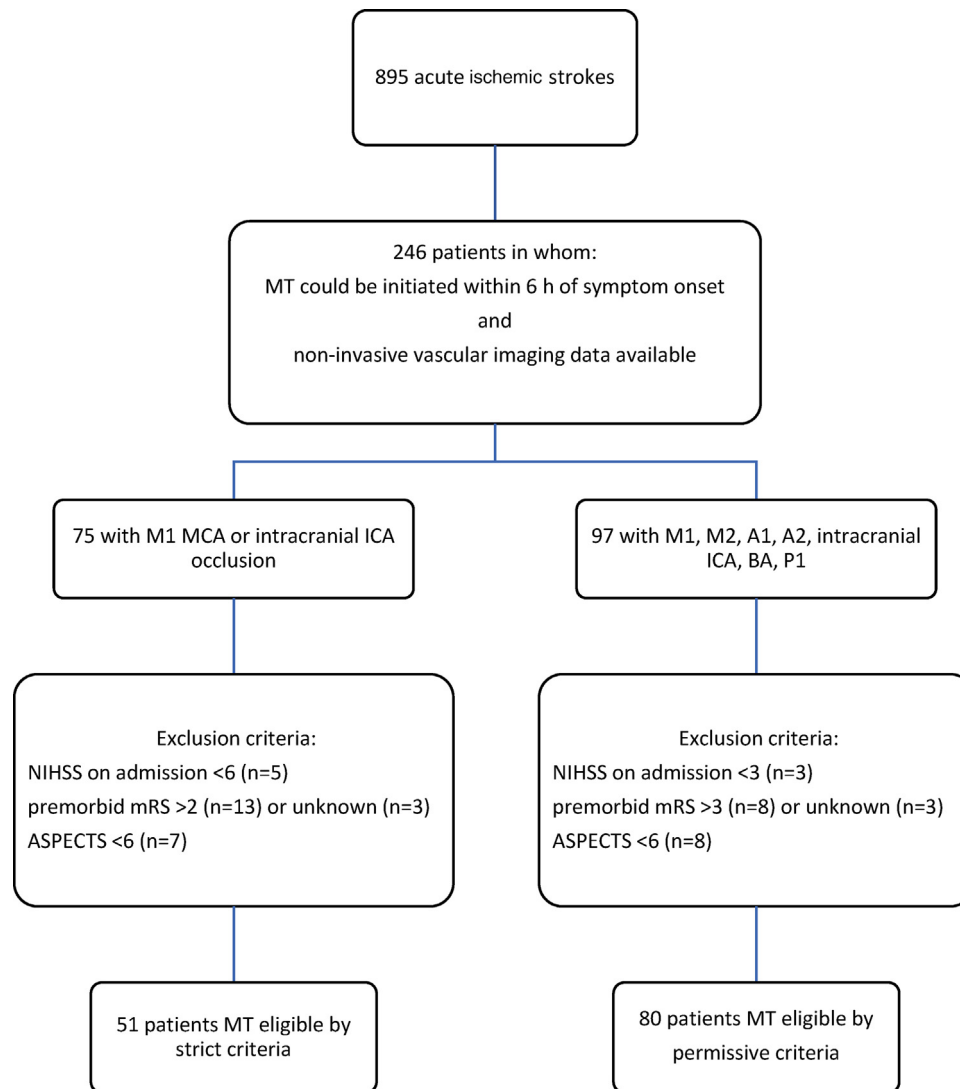
As shown, the MT-eligibility rates are highly dependent on the criteria used. The MCA and ICA occlusions are the only targets of clot retrieval with benefits of treatment unequivocally proven [11]. In our cohort, it accounted for three-quarter (n = 75/102) of causative LVOs. There is, however, some evidence from non-randomized studies that EVT of both M2 segment of MCA [12] and basilar artery [13,14] occlusions may result in high recanalization rates and good clinical outcomes. Our study demonstrates that considering MT in broader range of LVO cases (M2, A1, A2, BA, P1), could result in treating one more patient out of ten arriving within the treatment time window (12%). There is recently no solid evidence to support

this approach, but the clinical experience shows that it might be beneficial. Similarly, mild to moderate pre-stroke disability and low baseline NIHSS scores presumably should not be considered as an absolute contraindication to treatment, despite there is no clear data to confirm this statement [15].

Contrary to most of the other studies estimating MT eligibility [7,10,16], we set the limit of onset-to-evaluation time to 5 h to allow preparation of the procedure in 60 min. The optimization of in-hospital periprocedural organization would probably lead to more individuals treated. Employment of advanced imaging techniques might also affect the eligibility rates. Tissue viability assessment (CT perfusion, perfusion-diffusion MRI) improves patient selection as the infarct and penumbra sizes tend to correlate with functional outcomes [17]. It would decrease the eligibility of patients arriving within the given time limit, but some additional late-arriving individuals could be adequate for treatment based on penumbral size. There is currently insufficient high-quality evidence to recommend the routine usage of those imaging modalities in the qualification process.

According to our in-hospital stroke protocol, in the absence of contraindications, non-invasive vessel imaging within 5 h of AIS symptom onset is strongly recommended. The major weakness of our work is that we cannot accurately evaluate adherence to this point of protocol. We found that only 27.5% of all AIS patients (n = 246/895) underwent the examination in the given time frame. Based on our IVT treatment data, 94% (n = 189/201) of patients qualifying for intravenous thrombolysis had their CTA performed. It suggests that there was probably no substantial number of patients with the large vessel assessment omitted. Though, our results could be slightly overestimated due to possibility of excluding some subjects with low probability of being MT-eligible (e.g. with mild baseline deficit, high pre-morbid disability or extensive ischemic changes on initial CT) from such evaluation. It appears that the main reason for the small number of vessel imaging performed, was exceeding the EVT time window and not considering it as a treatment option. Hence, the significant amount of patients had lost their chances for effective reperfusion treatment due to pre-hospital delay. Reducing the onset-to-door time constitutes the primary point of potential improvement in the stroke care of our population. Efforts should be undertaken to solve this problem.

Since MT has become preferred treatment method for selected group of AIS patients, substantial re-organization of stroke care systems is much needed. Creating regional networks, comprising of primary and comprehensive AIS facilities is postulated [5]. The latter, with 24/7 access to EVT, should serve adequate population within a reasonable time range [4,18]. Therefore, data on eligibility and cost-effectiveness of MT are essential to provide basis for system planning [19]. Recent Australian population-based study predicted that 7 or 13% of all AIS patients may be candidates for EVT, depending on criteria restrictiveness [16]. It translated into  $\leq 22$  per 100 000 person-years. Similar estimations (11–22 per 100 000) were presented by Rai and colleagues within US population [20]. Our work is not a population-based study and the AIS cohort is not well-characterized, but with similar criteria applied, the eligibility rates could be roughly



**Fig. 1 – Acute ischemic stroke patients eligible for mechanical thrombectomy (MT) with application of two prespecified qualification algorithms. Each patient could meet more than one exclusion criterion. Abbreviations: AIS, acute ischemic stroke; ICA, internal carotid artery; MCA, middle cerebral artery; M1, first segment of middle cerebral artery; M2, second segment of middle cerebral artery; BA, basilar artery; P1, first segment of posterior cerebral artery; NIHSS, National Institutes of Health Stroke Scale; mRS, modified Rankin score; ASPECTS, Alberta Stroke Program Early CT Score.**

estimated to be 6 or 9%. These values are comparable with abovementioned analyses, which suggests that provided data could be cautiously used for stroke care system planning in Poland.

## 5. Conclusion

We found that, depending on inclusion criteria used, 21 or 33% of our AIS patients, whose onset-to-evaluation time allows to initiate mechanical thrombectomy within 6 h, could be eligible for treatment. It translates into about 6 and 9% of all AIS, respectively. It shows that substantial number of individuals is potential candidates for endovascular treatment and efforts should be made to achieve comparable rates in real life.

## Conflict of interest

None declared.

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None declared.

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