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Mechanical thrombectomy in acute stroke – Five years of experience in Poland

Polish Thrombectomy Initiative[1]

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ABSTRACT

Objectives: Mechanical thrombectomy (MT) is not reimbursed by the Polish public health system. We present a description of 5 years of experience with MT in acute stroke in Comprehensive Stroke Centers (CSCs) in Poland.

Methods and results: We retrospectively analyzed the results of a structured questionnaire from 23 out of 25 identified CSCs and 22 data sets that include 61 clinical, radiological and outcome measures.

Results: Most of the CSCs (74%) were founded at University Hospitals and most (65.2%) work round the clock. In 78.3% of them, the working teams are composed of neurologists and neuro-radiologists. All CSCs perform CT and angio-CT before MT. In total 586 patients were subjected to MT and data from 531 of them were analyzed. Mean time laps from stroke onset to groin puncture was 250 ± 99 min. 90.3% of the studied patients had MT within 6 h from stroke onset; 59.3% of them were treated with IV rt-PA prior to MT; 15.1% had IA rt-PA during MT and 4.7% – emergent stenting of a large vessel. M1 of MCA was occluded in 47.8% of cases. The Solitaire device was used in 53% of cases. Successful recanalization (TICI2b–TICI3) was achieved in 64.6% of cases and 53.4% of patients did not experience hemorrhagic transformation. Clinical improvement on discharge was noticed in 53.7% of cases, futile recanalization – in 30.7%, mRS of 0–2 – in 31.4% and mRS of 6 in 22% of cases.

Conclusion: Our results can help harmonize standards for MT in Poland according to international guidelines.

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1. Introduction

Since 2016, mechanical thrombectomy (MT) with new generation devices is an approved reperfusion therapy for acute ischemic stroke due to emergent large vessel occlusion [1]. Intra-arterial stroke treatment, either pharmacological [2] or mechanical [3,4], has been used for the last 20 years. The introduction of new generation devices (stent retrievers), which have been recognized as much more effective and safer than the old generation tools (MERCI retriever) [5,6], was a significant milestone in intra-arterial stroke treatment. The efficacy of

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these devices as compared to the best medical treatment, with IV rt-PA, where possible, was confirmed in 2015 by five prospective, randomized, open-label clinical trials: MR CLEAN [7], ESCAPE [8], EXTEND-IA [9], SWIFT PRIME [10], REVASCAT [11].

Based on estimates from Catalonia, Spain, the number of patients fulfilling inclusion criteria for MT averages 10:100 000 per year [12]. In Poland, with a population of 38.5 million, an estimated number of as many as 3800 acute stroke patients may fulfill criteria for MT each year.

According to the European Stroke Organization, in most European countries the number of tertiary stroke hospitals that provide MT on a 24/7 basis has grown significantly in the recent years [1]. Unfortunately, MT is not reimbursed by the Polish public health care system (the National Health Fund). Currently it is covered from the resources of the hospital where it is performed. The number of Stroke Units in Poland is sufficient to deliver standard stroke care, however, there is no formal network of the tertiary stroke centers in Poland. Interestingly, we were able to identify 25 stroke centers, in 15 out of 16 voivodeships in Poland and all of these centers fulfilled commonly accepted criteria for so-called tertiary stroke centers [13], and were able to perform MT when needed.

In this paper we present an evaluation of the five years of experience with MT treatment for acute ischemic stroke in Poland. In brief, we review both the organizational profile in the 23/25 centers that submitted the completed questionnaire and prospectively collected clinical databases of patients treated with MT in 22/25 of these centers in the context of their efficacy and safety.

2. Methods

We identified 25 stroke centers that treated acute ischemic stroke with MT with new generation devices between January 2012 and December 2016. Twenty-four centers agreed to participate in our study. Twenty-two centers both completed the structured questionnaire describing the procedures in the center and delivered their patients' raw data. One center only completed the structured questionnaire and provided information about the number of treated patients without providing further details ($n = 5$) and one did not fill the questionnaire, only providing information about the number of the treated patients ($n = 31$). Four stroke centers were identified in one voivodeship, three – in two voivodeships, two – in three voivodeships and one in nine voivodeships. One voivodeship lacks such a center.

Finally, we reviewed 23 local protocols. Each protocol included two common strategies for endovascular recanalization in case of acute large vessel occlusion: MT proceeded by IV rt-PA or primary MT in patients who had a contraindication to IV thrombolysis or presented within 4.5–8 h after stroke onset.

The leader of each stroke center completed the structured questionnaire, which allowed to determine differences between the centers with respect to center organization (work time, composition of the team) and protocol (for example, standard radiological procedures on admission and 24 h later, inclusion for MT based on patient's consciousness status, upper and lower National Institutes of Health Stroke Scale NIHSS [14] limits, upper age limit for MT, interval between stroke onset and groin puncture, interval between IV rt-PA administration and decision about MT, preprocedural pharmacotherapy, type of anesthesia during the procedure).

We gathered 22 different prospectively collected data sets. To minimize bias related to different local specificities of these data sets we reduced the number of analyzed parameters. Finally, we limited the list to 61 variables that were available from each center.

The following data were comprised on admission in each patient. Demographics: age and gender; clinical data: stroke etiology according to the Trial of Org10172 in acute Stroke Treatment (TOAST) criteria [15], stroke risk factors (hypertension, ischemic heart disease, myocardial infarction, atrial fibrillation, diabetes mellitus), stroke severity on admission assessed by the NIHSS [14]. Additionally, the following procedure data were collected: initial brain vessel imaging documenting site of large-vessel occlusion, time between symptom onset and groin puncture, treatment with IV rt-PA before MT, reasons for excluding patients from initial treatment with IV rt-PA, treatment with IA rt-PA during MT if needed, concomitant emergency stenting of large artery; type of device: Solitaire stent retriever (Medtronic, MN, USA), Penumbra aspiration system (Penumbra Inc., Alameda, CA, USA), Trevo stent retriever (Stryker Neurovascular, Fremont, CA, USA), ERIC (MicroVention Inc., Terumo), Catch (BALT Company), Preset (Phenox GmbH), Aperio (Acandis GmbH), or Revive – Codman Neuro (Johnson & Johnson).

Outcome data were divided into immediate (recanalization rate and posttreatment hemorrhagic complications) and early measures (stroke severity, neurological improvement, futile recanalization, modified Rankin scale score on discharge and in-hospital mortality) [16].

The recanalization results were assessed by digital subtraction angiography immediately after the procedure according to Thrombolysis in Cerebral Infarction (TICI) criteria: grade 0 – no perfusion; grade 1 – penetration with minimal perfusion; grade 2a – partial perfusion, <50%; 2b – partial reperfusion, ≥50–99%; grade 3 – no flow constraint and complete perfusion [17]. Successful reperfusion was defined as TICI2b-3.

Posttreatment hemorrhagic complications were classified according to the ECASS-1 classification [18]. Hemorrhagic infarction type 1 (HI1) was defined as small petechiae along the margins of the infarct and HI2 was defined as confluent petechiae within the infarcted area but no space-occupying effect. Parenchymal hematoma 1 (PH1) was defined as blood clots in ≤30% of the infarcted area with slight space-occupying effect, and PH2 was defined as blood clots in >30% of the infarcted area with substantial space-occupying effect. Stroke severity on discharge was assessed by the NIHSS.

Neurological improvement was defined as decrease of >4 points on the NIHSS on discharge as compared to stroke onset [19]. Disability on discharge was measured with the modified Rankin Scale, mRS [16]. Good clinical outcome was defined as a mRS score of 0–2 on discharge.

Futile recanalization, i.e. the proportion of patients without favorable outcome on discharge (neurological improvement of >4 point on the NIHSS) despite successful recanalization was also analyzed [20].

All-cause mortality on discharge was analyzed in all centers. All CSCs had the local ethical committee's agreement for performing MT in acute ischemic stroke.

2.1. Statistical analysis

Descriptive statistics included frequencies and percentage for categorical data and means and standard deviations (SD) for continuous variables. For some continuous variables, median and interquartile ranges were also calculated. All statistical analyses were performed using SAS 9.4 software.

3. Results

The 25 identified CSCs were established on the basis of stroke units at university hospitals or neurological institutes [17], state hospitals [2] or hospitals that had previously both required radiological equipment and served as leading local stroke centers. All CSCs had already had a neurovascular intervention unit in their structure.

Nine of the CSCs performed less than 10 MTs, four centers performed between 20 and 30 MTs, eight centers performed between 30 and 40 MTs, and two carried out over 40 MTs each. Fifteen out of the 23 CSCs included in the analysis (65.2%) worked round the clock. Eighteen out of 23 teams (78.3%) were composed of neurologists and neuroradiologists. All of the CSCs performed computed tomography and angio-CT of brain vessels before the MT procedure. Twenty CSCs (87.0%) additionally performed angio-CT of the extracranial vessels. After the MT procedure, all patients had a routine control CT scan of the brain within 48 h after stroke onset. In 15 centers (65.2%) there was no upper age limit for the procedure established. An inclusion NIHSS score was specified in 8 centers (34.8% of the studied group). In 17 centers (73.9% of the studied CSCs) the upper limit for the time lapse between stroke onset and groin puncture was set at 8 h, in the remaining 6 centers (26.1% of the studied CSCs) – a longer time window was accepted in special situations, like stroke located in the vertebrobasilar region. In 18 centers (78.3% of the studied CSCs) the interval between IV rt-PA administration and the decision about implementing MT was not longer than 60 min. Only in 3 centers (13.0%) heparin was routinely used before the procedure. Twelve centers (52.2%) accepted local anesthesia and 11 – general anesthesia. Detailed information about the centers' organization is shown in Table 1.

In total 586 patients were subjected to MT in the 25 identified centers. Raw data was obtained from 550 cases and 531 cases were finally included in the analyses, because they had the minimum set of data (age, gender and mRS on discharge). The baseline characteristics, including age, percentage of female patients, initial NIHSS score, stroke risk factor profile and stroke etiology of all patients included in the analyses are shown in Table 2. Twenty-seven patients (5.1% of the analyzed cases) were subjected to MT in 2012, 62 (11.7%) in 2013, 63 (11.9%) – in 2014, 111 (20.9%) – in 2015 and 268 (50.5%) – in 2016.

Information on the time lapse between stroke onset and the groin puncture was available in 504 patients (95% of analyzed cases). Mean time lapse was 250 ± 99 min (range: 60–885 min). Four hundred fifty-five (90.3%) patients had MT performed within 6 h after stroke onset, 42 (8.3%) – within 6–8 h, and 7 subjects (1.38%) had the procedure performed later than 8 h from stroke onset.

Table 1 – Stroke center characteristics.

Characteristics	N (%)
Patients eligible for thrombectomy	
Only those who were able to sign informed consent	1 (4.3)
Only those who were able to sign informed consent or who were able to confirm their will in the presence of two witnesses	3 (12.9)
All patients, including those with aphasia or unconsciousness	19 (82.6)
Center organization	
24/7	15 (65.2)
Only working hours	2 (8.6)
Only when the required personnel is available	6 (26.1)
Team composition	
Neurologist plus interventional radiologist	18 (78.3)
Neurologist plus neurosurgeon	3 (12.9)
Neurologist plus vascular surgeon	1 (4.3)
Neurologist plus radiologist plus neurosurgeon	1 (4.3)
Neurologist plus cardiologist	1 (4.3)
Standard radiological admission procedures	
Cranial computed tomography without contrast	23 (100)
Computed tomography with contrast	2 (8.6)
Angio-tomography, brain arteries	23 (100)
Angio-tomography, neck arteries	20 (87.1)
Perfusion tomography	1 (4.3)
Magnetic resonance	6 (25.1)
Routine radiological procedures after mechanical thrombectomy	
Yes, routinely 24 h after the procedure	20 (87.1)
Yes, routinely 48 h after the procedure	3 (12.9)
No	0
Upper age limit for stroke patients eligible for mechanical thrombectomy	
<80 years	6 (26.1)
<85 years	2 (8.6)
No age limit	15 (65.2)
Lower NIHSS limit for inclusion	
>5	5 (21.7)
>7	2 (8.6)
>9	1 (4.3)
No limits	15 (65.2)
Interval between stroke onset and groin puncture	
<6 h	3 (12.9)
6–8 h	14 (61.0)
>8 h accepted in special situations	6 (26.1)
Undetermined	
Delay to assess IV rt-PA-induced recanalization before endovascular treatment	
30 min	10 (43.5)
30–60 min	8 (34.8)
>60 min	5 (21.7)
Pharmocotherapy immediately before MT	
Aspirin	0
Aspirin plus heparin	0
Heparin	3 (12.9)
Non	20 (87.1)
Type of anesthesia	
Local	12 (52.2)
General	11 (47.8)
Both	0

Table 2 – Clinical characteristics and procedural parameters of all patients.

Characteristics	
Age, *y*	66.6 (13.7)
Female gender, *n* (%)	273 (51.4)
NIHSS score on admission, median IQR *n* = 523/531 (98.5)	16 (12–19) (min: 0–max: 42)
Vascular risk factors	
Hypertension, *n* (%)	338 (73.1)
Ischemic heart disease, *n* (%)	156 (29.4)
Myocardial infarction, *n* (%)	64 (12.1)
Atrial fibrillation, *n* (%)	246 (46.3)
Diabetes mellitus, *n* (%)	140 (26.4)
Stroke etiology	
Large vessel disease	124 (23.4)
Small vessel disease	0
Cardioembolic stroke	195 (36.7)
Not known	187 (35.2)
Rare	25 (4.7)
IV rt-PA status	
IV rt-PA before mechanical thrombectomy	315 (59.3)
No IV rt-PA before mechanical thrombectomy due to treatment window	64 (12.1)
No IV rt-PA before mechanical thrombectomy due to VKA treatment	31 (5.8)
No IV rt-PA before mechanical thrombectomy due to NOAC treatment	14 (2.6)
No IV rt-PA before mechanical thrombectomy due to any antithrombotic treatment	18 (3.4)
Other reasons	89 (16.8)
Concomitant treatment procedures during thrombectomy	
IA rt-PA during the procedure	80 (15.1)
Emergent stenting of extracranial arteries	25 (4.7)
Occlusion site	
Carotid T occlusion, *n* (%)	85 (16.0)
M1 middle cerebral artery, *n* (%)	254 (47.8)
M2 middle cerebral artery, *n* (%)	65 (12.2)
M3 middle cerebral artery, *n* (%)	6 (1.1)
A1 anterior cerebral artery, *n* (%)	1 (0.2)
A2 anterior cerebral artery, *n* (%)	0
Vertebrobasilar arteries, *n* (%)	72 (13.6)
Multiple	46 (8.7)
Missing data	2 (0.4)
Type of thrombectomy device	
Solitaire (Medtronic, MN, USA), *n* (%)	282 (53.1)
Penumbra (Penumbra, Alameda, CA, USA), *n* (%)	76 (14.3)
CATCH (BALT), *n* (%)	42 (7.9)
Eric (MicroVention Inc., Terumo), *n* (%)	32 (6.0)
Preset (Phenox GmbH), *n* (%)	9 (1.7)
Aperio (Acandis GmbH), *n* (%)	8 (1.5)
Revive – Codman Neuro (Johnson & Johnson), *n* (%)	6 (1.1)
Trevo (Stryker Neurovascular, CA, USA), *n* (%)	4 (0.7)
Several, *n* (%)	26 (7.9)
Missing data, *n* (%)	46 (8.7)
Immediate outcome measures: TICI score	
0, *n* (%)	79 (14.9)
1, *n* (%)	27 (5.1)
2a, *n* (%)	62 (11.7)
2b, *n* (%)	80 (15.1)
3, *n* (%)	262 (49.5)
Missing data, *n* (%)	21 (4.0)
Immediate outcome measures: hemorrhagic transformation	
No hemorrhagic transformation	284 (53.4)
HI1, *n* (%)	50 (9.4)
HI2, *n* (%)	34 (6.4)
PHI1, *n* (%)	43 (8.1)
PHI2, *n* (%)	38 (7.2)
Missing data, *n* (%)	82 (15.4)
Early outcome measures on discharge	
NIHSS score on discharge, median IQR	6 (0–42)
Clinical improvement on discharge (>4 points in NIHSS), *n* (%)	285 (53.7)
Modified Rankin Scale 0, *n* (%)	48 (9.0)
Modified Rankin Scale 1, *n* (%)	65 (12.2)
Modified Rankin Scale 2, *n* (%)	54 (10.2)
Modified Rankin Scale 3, *n* (%)	65 (12.2)
Modified Rankin Scale 4, *n* (%)	86 (16.2)
Modified Rankin Scale 5, *n* (%)	96 (18.1)
Modified Rankin Scale 6, *n* (%)	117 (22.0)

Three hundred fifteen (59.3%) patients were pretreated with IV rt-PA prior to the MT. Contraindications to IV rt-PA administration before MT are listed in Table 2. Eighty patients (15.1% of analyzed cases) had IA rt-PA administered during the procedure and 25 patients (4.7% of analyzed cases) had emergent stenting of a large vessel performed. Detailed sites of vessel occlusion are listed in Table 2. In most patients (53% of cases) MT was performed using the Solitaire device. Successful recanalization (TICI2b and TICI3) was obtained in 322 patients (64.6%). Lack of hemorrhagic transformation on the followed-up imaging check was found in 53.4% of patients. The details are shown in Table 2.

117 patients (22% of cases) died during hospitalization. We analyzed the individual mortality rate for the 13 out of the 22 centers which treated at least 10 cases. We found 4 centers with a discharge mortality rate >25%; three with a mortality rate between 20% and 25%, and 6 with a mortality rate <20%.

Clinical improvement was noticed in 285 cases (53.7% of patients). Futile recanalization occurred in 30.7% of cases. Good functional outcomes (mRS 0–2) on discharge were achieved in 167 patients (31.4% of analyzed cases).

4. Discussion

In this paper we present a nationwide cohort of patients treated with MT using new generation devices. This is an analysis of real life experience, starting from 2012, a few years before this therapy was universally approved [1]. Interestingly, only 30% of all the studied patients were subjected to MT before the publication of the milestone papers in 2015 [7–11] and half of the patients – after the publication of the current guidelines [1]. Since MT is currently not reimbursed in Poland and access to this treatment is not common and varies from region to region and not all CSCs performing MT participated in the survey, the presented analysis does not provide epidemiological data on this procedure in Poland.

However, we were able to summarize the detailed organizational structure and diagnostic and treatment

protocols of the CSCs in Poland. These CSCs rose up on the basis of existing well-recognized, experienced and well-equipped stroke units remaining in close collaboration with vascular intervention units. From the financial point of view this transformation was cost-free. Interestingly, in spite the lack of central financial support, most CSCs worked round the clock. Labor cost and cost of devices for the MTs were covered by the local hospitals.

All the included CSCs follow the consensus statement by ESO-Karolinska Stroke Update 2014/2015 [1] in respect to the fundamental requirements for treatment recommendations for MT: introduction of treatment with MT only when there is a contraindication for IV rt-PA or the therapeutic window for IV rt-PA administration is prolonged (100%); team composition of stroke neurologists and neuroradiologists or neurosurgeons (96%); treatment decision issued by multidisciplinary team (100%); expanded radiological work-up before MT (100%) or employment of new generation devices for MT (100%).

It should be underlined that only in 3 of the studied CSCs (13%) the accepted time lapse between stroke onset and groin puncture equaled 6 h and 6 of the centers (26%) accepted a longer time than 8 h in special situations. However, even if the accepted therapeutic window was wider than 8 h, we found that 90% of patients were treated still within the 6 first hours, as recommended in the current guidelines. Only 7 patients (1.3%) were treated more than 8 h after stroke onset – five had the thrombus located in the basilar artery and two had severe stroke in the anterior circulation. It would be an important improvement to harmonize the upper limit for MT in all centers to the 6-h therapeutic window as it is recommended in the present guidelines. According to recently published data from a multicenter stroke registry in China comprising 632 patients who underwent endovascular treatment due to acute middle cerebral artery occlusion, a time delay between stroke onset and groin puncture greater than 270 min is associated with risk of symptomatic intracranial hemorrhage (OR = 1.70, 95%, CI: 1.03–2.80) which, concomitantly, significantly increases 90-day mortality in these patients [21]. MT beyond 6 h may be reasonable only in special circumstances, including basilar artery occlusion, where such treatment could result in a high recanalization rate and favorable outcome [22].

Interestingly, in almost all centers (87%) no antithrombotic treatment was used before or during the procedure. The literature concerning periprocedural antithrombotic therapy in MT is scarce [22]. However, in most of the studied stroke centers, neither heparin, nor aspirin were used before MT, especially if the procedure was preceded by IV rt-PA administration [23]. Among the five milestone papers concerning MT published in 2015, only the REVASCAT trial paper stated that systemic anticoagulation was not allowed other than in the form of heparinized saline infusion as per local interventional procedure standards [11]. However, this precaution did not result in an increase of intracerebral bleeding complications as compared to the other four trials. On the other hand, the protocol of the French cohort study evaluating MT with the ERIC retrieval device in patients with acute ischemic stroke allowed the use of an IV heparin bolus administered at the beginning of the procedure in patients without preceding IV rt-PA, which resulted in greater risk of hemorrhagic transformation (12%) than in the previously reported studies (5–7%) [24]. The most recent ESO [1] and AHA/ASA [25] guidelines do not give any practical clues to the issue of periprocedural antithrombotic therapy in MT.

There is no preference as to the type of anesthesia during MT in Poland. Meanwhile, in all the five milestone MT studies published in 2015 [7–11] and according to most nationwide registries, local sedation was used more frequently than general anesthesia with intubation. Previous studies also revealed that clinical outcomes and survival were significantly better in patients treated with local sedation in comparison to subjects undergoing general anesthesia, because they did not involve increased risk of symptomatic intracranial hemorrhage [26,27]. The ESO guidelines cite the expert consensus statement of the Society of Neurointerventional Surgery and the Neurocritical Care Society, which recommends using general anesthesia only in patients with severe agitation, low level of consciousness (GCS $<$ 8 pts), loss of airway protective reflexes or respiratory compromise and in selected posterior circulation stroke patients presenting with these features [28,29].

To improve patient selection according to published recommendations [1], imaging of penumbra size should be performed more commonly. So far, in the presented data only one center performed perfusion CT routinely. What is more, the patients' ASPECTS (Alberta Stroke Program Early CT score) should be routinely evaluated to help the process of patient selection. Nearly all previous studies and nationwide registries used ASPECTS scores in the qualifying process for MT and their practical implementation has been lately recommended in the ESO [1] and AHA/ASA [25] guidelines.

According to the current guidelines, older age is not a reason to withhold MT for adjunctive treatment. We found, however, that that 8 out of 23 centers (23%) still used an upper age limit for patient selection. It cannot be excluded that the reason for that is limited access to the procedure in Poland, therefore younger patients with stroke are the ones who are qualified with preference for MT.

Even though our study does not provide epidemiological data on MT in Poland, it can be noted that our patients showed similar demographics, stroke risk factor profiles and stroke etiology as the groups described in previously published clinical trials and real-life data studies. Moreover, the number of patients treated with IV rtPA before the procedure (59.3%) was also similar to that in most previous studies, in which it varied from 46% to 68% of all studied patients. In two clinical trials, MRCLEAN [7] and ESCAPE [8], the percentage of patients treated with IV rt-PA before MT was higher than in our cohort and equaled 87% and 73% of all studied patients, respectively, whereas in two other studies, EXTEND [9] and SWIFT [10], due to characteristics of the protocol, intravenous thrombolysis preceded MT in all cases.

It is important to underline that 63 of the analyzed patients underwent MT due to the fact that they were under the influence of antithrombotics used to treat concomitant atrial fibrillation. MT is the only available causative treatment for this subgroup of patients. There is little data on this topic in the literature. In a recent study, MT in patients receiving anticoagulants achieved similar efficacy as in those without a previous history of antithrombotic intake. There was, however, a non-significant trend toward greater incidence of symptomatic intracranial hemorrhage and lower mortality

in such patients. According to the authors of this study, one possible explanation of this finding was that clots due to cardioembolic stroke could be removed more easily than the atherothrombotic ones [30].

In the current study we were able to compare only immediate and early outcome measures to those published in the literature. Successful recanalization defined as a TICI score of 2b or 3 was achieved in 64.6% of cases. Most previous MT trials showed higher successful recanalization rates, reaching from 72% to 88% [7–11]. On the other hand, the median NIHSS score on discharge (6 points) was similar to that reported in previous studies 24 h after the procedure (4–6 points) [8,31]. Moreover, the percentage of patients that improved by 4 or more points in the NIHSS on discharge was similar to that recorded in a Swedish cohort (58.6% vs. 63%) [32]. Unfortunately, in-hospital mortality in the presented case series was high (22%). This result does not seem to be related to the initial neurological deficit, since the median NIHSS score on admission was comparable to that previously reported in clinical studies and case series. We analyzed in detail the possible reasons for a high (>25%) in-hospital mortality in four of the studied centers. We found that one of them had included patients with significantly more severe neurological deficits on admission (median NIHSS: 18) as well as significantly more patients with vertebrobasilar thrombus location (26% of all treated patients) as compared to others. Another one of these four centers also included a higher percentage of patients with thrombus located in vertebrobasilar arteries (22.7%). The third center's data comprised cases with significantly more severe neurological deficits on admission. Interestingly, the fourth of these centers – which had a 36.4% in-hospital mortality rate – had a significantly longer average time from stroke onset to groin puncture as compared to other included centers (330 min, IQR: 240–390 vs 240 min, IQR: 180–300; $p < 0.05$).

Unfortunately, only two centers systematically collected 90-day outcome data (in total = 178), thus, we were not able to show this valuable information for all included patients. In the first center in-hospital mortality was 18.3% and 90-day mortality – 21.2%, in the second center – 23% and 28.4%, respectively. The rate of 90-day mortality seems comparable to that previously reported in other national MT registries from Austria and Brazil (20.9% and 23%, respectively) [33,34].

A limitation of the presented study is the inclusion of retrospectively collected patient data drawn from 23 different protocols. What is more, the collected data were not verified centrally, which could bias the results.

5. Summary/conclusion

Our study allowed to describe a cross country real-life experience in treatment of acute stroke with MT and highlighted the pros and cons of the used protocols. These results can help harmonize standards of care in acute ischemic stroke patients in Poland according to available guidelines.

Conflict of interest

None declared.

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None declared.

Ethics

The work described in this article has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans; Uniform Requirements for manuscripts submitted to Biomedical journals.

Appendix

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