

SUMMARY

Introduction

Cerebrovascular disease is one of the most common causes of death in the world. They cause disability of millions of people each year, creating a global economic burden and therefore posing an important challenge for health organizations. This justifies the need to search for more effective therapeutic methods and to ensure their maximum availability.

AIS is caused by a disturbance in blood flow in the brain that leads to irreversible damage to the brain's tissues. Therefore, the main goal of treatment is to restore blood flow to areas at risk of necrosis. Intravenous thrombolysis and mechanical thrombectomy are the cornerstones of current therapy, the latter being used in selected patients with radiographically proven large vessel obstruction. Despite convincing evidence of its effectiveness, up to half of the patients undergoing endovascular therapy still do not achieve favorable functional outcomes, mainly due to its consequences on brain tissues. These include, first of all, the follow-up infarct volume, as well as hemorrhagic complications and cerebral edema. Therefore, the identification of factors that may influence their occurrence plays an important role.

One of the important parameters determining the treatment outcome are blood pressure values, both at the baseline and during the therapeutic intervention. Optimal target blood pressure values during EVT in AIS, however, remain controversial. The analysis of studies to date suggests that both hypotension and hypertension during endovascular intervention in AIS are associated with poorer functional outcomes. The variability of hemodynamic parameters also has a significant impact on the evolution of the ischemic focus. However, data on this topic are quite limited, which underscores the rationale for further targeted research on this problem.

Objective of the work

The aim of the study is to assess the relationship between arterial pressure parameters during mechanical thrombectomy performed in patients with AIS and the follow-up infarct volume, cerebral edema and hemorrhagic complications imaged using computed tomography 24 - 36 hours after the procedure.

Patients and methods

The medical records of 1,540 patients diagnosed with AIS who were hospitalized at the Interventional Stroke Treatment Center (CILUM) of the Department of Neurology of the Second Provincial Hospital in Rzeszów in the period from December 1, 2018 to March 31, 2021 were analyzed retrospectively. The final study group consisted of 214 patients who met the eligibility criteria for the study. These included the diagnosis of ischemic stroke due to ICA or MCA1 obstruction treated by mechanical thrombectomy under general anesthesia.

Blood pressure was measured in an automatic, non-invasive way. The first measurement was carried out immediately after the patient's arrival at CILUM, while the periprocedural blood pressure values were determined by measurements taken at 5 - minute intervals throughout its duration and 5 minutes after the end of the procedure. Each reading included two values (SBP and DBP). Subsequently, the analysis of individual blood pressure parameters was performed, which included: SBP/DBP/MAP on admission, maximum SBP/DBP/MAP during the procedure before successful recanalization (or termination of treatment in its absence), as well as the difference between these parameters and the baseline blood pressure. The amplitude of the arterial pressure value obtained from the measurement, in which the highest value of systolic arterial pressure during the procedure and the time below or above a certain threshold value of systolic and mean arterial blood pressure were found.

The radiological assessment was performed based on control imaging of the brain performed routinely 24 - 36 hours after the start of treatment, or possibly earlier in the event of significant clinical deterioration. The control consisted of performing non - contrast computed tomography. The analysis of the ischemic focus evolution after MT treatment included the follow - up infarct volume, the presence of cerebral edema and secondary haemorrhage.

The statistical analysis of the collected material was performed in the Statistica 13.3 package by StatSoft. $P < 0,05$ was considered statistically significant.

To conduct the research used in this study, the approval of the Bioethics Committee of the University of Rzeszów was obtained (No. 2022/050).

Results

The study group included 101 (47.2 %) women and 113 (52.8 %) men aged 28 to 92 years. Atrial fibrillation and heart failure were among the dominating risk factors of ischemic stroke, and the most common etiology was of cardio - embolic origin. Most patients were treated with thrombolytic therapy with MT - 154 (72.0 %), and as a result of the interventions, 85 % of patients were successfully recanalized.

In the analysis of blood pressure variability during the MT procedure, particular attention was paid to the presence of blood pressure drops in almost all subjects, while the share of patients experiencing BP reduction was inversely proportional to the percentage of BP reduction. In the case of a decrease in both SBP and MAP by 10 %, it was observed in 92 % of respondents, while a decrease by 40 % was found only in 36.0 % of people.

Regarding the consequences of acute ischemic stroke, computed tomography imaging showed a statistically significant correlation between the baseline SBP and FIV values ($p = 0,014$) in the group of patients treated with mechanical thrombectomy. This relationship was also confirmed in the multiple regression model, after adjustment for other known unfavorable prognosis factors ($b = 0,84$; 95 % CI 0,10 – 1,58; $p = 0,026$). For every 10 mmHg increase in SBP, FIV increased by 8.4 ml. FIV was also significantly influenced by the percentage difference between the extreme momentary SBP values ($p = 0,035$) and the amplitude of the blood pressure value from the measurement, in which the highest SBP value was found ($p = 0,043$). Importantly, on the basis of the conducted analyzes, the independent effect of the maximum SBP decrease in relation to the initial value on the control infarct volume was confirmed ($b = 0,72$; 95 % CI 0,05 – 1,37, $p = 0,029$).

The reduction in MAP and SBP values in relation to their initial values was also assessed in percentages, while setting successive thresholds from 0 to greater than 40 %. On this basis, it was shown that pressure drops greater than 40.0% of the initial pressure value MAP ($b = 42,7$; 95 % CI 2,89 – 82,62; $p = 0,036$) and SBP ($b = 40,17$; 95 % CI 0, 64 – 79,70, $p = 0,046$) were an independent factor influencing FIV. However, this parameter is influenced not only by the very fact of the occurrence of hypo - or hypertension, but also by their duration. The presence of statistically significant positive relationships between FIV and the time spent by patients in the range of pressure values below 100 mmHg MAP ($p < 0,001$), below 90 mmHg MAP ($p = 0,001$) and below SBP 140 mmHg ($p = 0,033$). Additionally, the residence times in the pressure range below the MAP 100 mmHg ($b = 0,71$; 95 % CI 0,31-1,11, $p = 0,001$) and below

the MAP 90 mmHg ($b = 0,6$; 95 % CI 0,16 - 1,03, $p = 0,007$) were an independent factor influencing FIV after adjustment for other factors of unfavorable prognosis.

Maximal SBP also significantly influenced the presence of bleeding complications. In the group of patients who experienced haemorrhage, a higher median of maximum SBP values was observed (median 160 mmHg vs 157 mmHg). There was also a statistically significant relationship between the amplitude of the blood pressure value obtained from the measurement, where the highest SBP value was found, and a shift towards higher values of the results obtained in the scale assessing bleeding complications ($p = 0,011$). The shift in the secondary hemorrhagic scale also depended on the time the patients stayed in the range of arterial pressures above the SBP 160 mmHg ($p = 0,044$). After considering other factors influencing the AIS sequelae in the logistic regression analysis, such as age, place of obstruction, recanalization status, OTG, and NIHSS on admission, it was found that an independent risk factor for bleeding complications was the time when patients' SBP remained above the threshold of 140 mmHg ($p = 0,009$) and 160 mmHg ($p = 0,003$). With each additional minute above the threshold SBP of 160 mmHg, the risk of developing bleeding complications increased by approximately 8,8 %, and above the threshold SBP of 140 mmHg by approximately 3,5 %.

In the studied group, no correlation was found between the initial blood pressure values and the occurrence of cerebral edema. Similarly, the extreme values of blood pressure did not affect the shift towards higher values of the COED scores. On the other hand, the maximum increase in SBP from the initial value expressed as a percentage significantly influenced the presence of cerebral edema ($p = 0,049$). There was also a correlation between a shift towards higher cerebral edema scores and drops in blood pressure greater than 40,0 % of the baseline MAP ($p = 0,014$). In addition, the time below the MAP threshold of 100 mmHg was an independent risk factor for cerebral edema (OR 1,010; 95 % CI 1,00 – 1,01; $p = 0,009$) and displaced cerebral edema (OR 1,006; 95 % CI 1,00 – 1,0; $p = 0,043$). With each additional minute below the MAP threshold of 100 mmHg, the risk of developing cerebral edema increased by about 1 %, and for brain edema with displacement by about 0.6 %.

Summary of results

1. During mechanical thrombectomy performed under general anesthesia, the vast majority of patients experience a drop in blood pressure.
2. Blood pressure drops during mechanical thrombectomy procedures are much more frequent than blood pressure increases.
3. Higher values of initial systolic blood pressure are independently associated with higher follow-up infarct volume determined by CT scans performed 24 - 36 hours after treatment.
4. There was no significant association between initial systolic, diastolic and mean blood pressure values and the risk of secondary hemorrhage and symptomatic hemorrhage.
5. There was no association between the minimum value of systolic, diastolic and mean blood pressure with any of the sequelae of ischemic stroke evaluated in the follow-up study after mechanical thrombectomy.
6. The group of patients who were observed to have secondary hemorrhage was characterized by higher values of maximum systolic blood pressure during endovascular treatment.
7. The higher amplitude of systolic and diastolic blood pressure values derived from the measurement with the highest systolic blood pressure value during MT is associated with a significantly higher risk of secondary hemorrhage and symptomatic hemorrhage, as well as a larger volume of ischemic focus assessed by follow - up computed tomography scan.
8. The magnitude of the decrease in systolic blood pressure from baseline independently influenced the larger follow - up infarct volume assessed by computed tomography after mechanical thrombectomy.
9. There was no effect of maximum increase in systolic, diastolic and mean blood pressure from baseline on follow - up infarct volume or risk of hemorrhagic complications.

10. Expressed as a percentage, the maximum increase in systolic blood pressure from the initial value during mechanical thrombectomy significantly affects the risk of cerebral edema.

11. A momentary decrease in systolic and mean arterial blood pressure $> 40\%$ of the initial value independently influences a greater control infarct volume as assessed by computed tomography, while a decrease in mean arterial blood pressure $> 40\%$ significantly contributes to a shift towards higher COED scores for cerebral edema.

12. There was no correlation between the temporary decrease in systolic and mean blood pressure from the initial value and the presence of secondary hemorrhage, including the occurrence of symptomatic hemorrhage.

13. The consequences of ischemic stroke assessed in imaging studies after treatment with mechanical thrombectomy are influenced not only by the occurrence of hypo- and hypertension, but also by their duration.

14. The cumulative time of mean arterial blood pressure below the threshold of 100 mmHg during mechanical thrombectomy is an independent risk factor for cerebral edema and cerebral edema with displacement of the midline to the opposite side. On the other hand, the time below the threshold of 90 mmHg influences the increase in the infarct volume as assessed in the control study, regardless of other factors.

15. An independent risk factor for the occurrence of bleeding complications (but not symptomatic bleeding) is the cumulative duration of mechanical thrombectomy, systolic blood pressure above the threshold of 140 mmHg and 160 mmHg during mechanical thrombectomy.

Conclusions

1. Blood pressure should be monitored systematically during a mechanical thrombectomy in a patient suffering from acute ischemic stroke.

2. When performing mechanical thrombectomy on a patient with acute ischemic stroke, it is imperative to limit both the changes in blood pressure and the time during which abnormally low or elevated blood pressure values persist.

3. A decrease in blood pressure during mechanical thrombectomy in an acute ischemic stroke patient as a percentage of the baseline value may be a prognostic factor as it is a better indication of the probability of an ischemic enlargement than an absolute decrease in blood pressure.

4. It seems justified to conduct a prospective, randomized study evaluating the management of blood pressure during thrombectomy in acute ischemic stroke with occlusion of large intracranial vessels, in relation to the consequences of stroke identified by imaging studies.

Key words: ischemic stroke, mechanical thrombectomy, follow - up infarct volume, hemorrhagic complications, cerebral edema, arterial blood pressure.