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The effect of anesthesia on hemodynamics and outcome of patients undergoing thrombectomy after acute ischemic stroke: a retrospective analysis

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KEY WORDS

Anesthesia, Hemodynamic monitoring, Hypotension, Stroke

Abbreviations

AIS	Acute Ischemic Stroke
IV	Intravenous
tPA	tissue plasminogen activator
MT	Mechanical thrombectomy
MAC	Monitored anesthesia care
MAP	Mean Arterial Pressure
mRS	Modified Rankin Scale
TIVA	Total Intravenous Anesthesia

ABSTRACT (250/250 words)

Background:

Anesthesia during thrombectomy remains a matter of debate. We retrospectively investigated the influence of intraprocedural blood pressure and type of anaesthetic agent on 3-month functional outcome and mortality in stroke patients undergoing mechanical thrombectomy under general anesthesia in a single center study.

Methods:

All patients suffering from stroke who presented between January 2019 to July 2021 at Ziekenhuis Oost-Limburg Genk, Belgium and who received thrombectomy were included.

Patient's characteristics and outcome data had been collected for benchmarking. Detailed perioperative data were exported from the electronic anesthesia records and clinically validated. Patients were stratified by peri-operative presence of hypotension (MAP <65mmHg at any time point) versus no-hypotension (MAP ≥ 65mmHg).

Results:

All 98 patients received mechanical thrombectomy under general anesthesia. Thirty-six percent (n=35) was hypotensive peri-operatively at any time point. Proportion of sevoflurane use was higher in non-hypotensive patients compared to hypotensive patients (73% (n=45) vs. 51% (n=18), p=0.04). Peri-operative use of vasopressors was higher in the hypotensive group compared to non-hypotensive (88% (n=30) vs. 63% (n=39), p=0.008). Proportion of patients with good functional outcome at 3 months (mRS 0-2) was higher in non-hypotensive patients compared to hypotensive patients 44% (n=27) vs. 24% (n=8), p<0.05. 90-day mortality was lower in non-hypotensive patients compared to hypotensive patients 21% (n=13) vs. 43% (n=15), (p=0.02).

Conclusion:

Patients who are hypotensive at any given time during thrombectomy under general anesthesia may have worse neurological outcome compared to non-hypotensive patients. The best anaesthetic management for mechanical thrombectomy needs to be clarified prospectively in large multicenter studies.

Introduction

Management of patients with acute ischemic stroke (AIS) consists of early recognition using a stroke severity scale, early head and neck imaging, immediate therapy with intravenous (IV) administration of tissue plasminogen activator (tPA) if no contraindications are present and may be followed by mechanical thrombectomy (MT). This cascade requires extensive multidisciplinary collaboration where timing is crucial to pursue a favorable neurological outcome [1,2].

In selected patients with an AIS caused by a large vessel occlusion, MT is the recommended treatment, if no contra-indications are present [3]. This procedure can be performed under general anaesthesia or conscious sedation (monitored anesthesia care, MAC). Some observational studies found worse neurological outcome in patients receiving general anaesthesia for MT, although the exact mechanism remains unclear [4–6]. Post-induction hypotension due to the side effects of most anaesthetic agents, could be one reason for this observation [7]. However, recent trials showed no difference in neurological outcome when patients received general anaesthesia [8–10]. Although there is no conclusive evidence, current research suggest that implementing general anaesthesia for endovascular therapy is now considered as safe alternative with less concern about adverse effects on patient outcome [2].

The 2019 update of the 2018 AHA/ASA stroke guidelines recommend to maintain a systolic blood pressure (BP) of 140mmHg or more at all times in patients scheduled for and during MT. Due to possible damage and dysfunction of the blood-brain barrier, perfusion of the brain during AIS is directly related to blood pressure. However, the minimal BP that should be maintained in patients with AIS for the best neurological outcome is not known. Hypotension and hypovolemia should be avoided and must be corrected to maintain systemic perfusion pressure [1]. Moreover, it has been shown that risk of unfavorable outcome increases significantly when the MAP is below 65mmHg during surgery [11].

Today, it remains unclear which factors contribute to worse neurological outcome in patients undergoing general anaesthesia during endovascular treatment for AIS with a large vessel occlusion. Hence, we investigated if there is an independent association between absolute hypotension (mean arterial BP<65mmHg) and long-term neurological outcome as well as the type of anesthesia which could influence neurological outcome.

Methods

Patient characteristics

All patients, who were admitted with ischaemic stroke at Ziekenhuis Oost-Limburg, Genk, Belgium and underwent MT between January 2019 until July 2021, were included in this study. All patient data were collected by reviewing the Electronic Medical Record System (HiX, ChipSoft, Amsterdam, The Netherlands). Local Ethics committee approval was obtained prior to data retrieval (19/0059U).

Baseline patient characteristics (age, sex) and the cardiovascular risk factors pre-existing hypertension (defined as use of anti-hypertensive drugs pre-stroke), presence of atrial fibrillation and dyslipidemia (defined as use of statins pre-stroke) were collected. Also the modified Rankin score (mRS), both pre-stroke and at 3 months after admission for ischemic stroke, had routinely been collected in the framework of benchmarking stroke outcome.

Severity of stroke was scored using the National Institute of Health Stroke Scale (NIHSS), calculated by the on-call neurologist at the time of presentation in the Emergency Department. The operational stroke performance indicators door-to-needle time and door-to-groin time were also retrieved.

Intra-operative management

According to international and local hospital protocol, all patients underwent general anesthesia with endotracheal intubation. Maintenance of anesthesia was done either by volatile (sevoflurane with or without nitrous oxide) or total intravenous anesthesia, at the discretion of the treating anesthetist [1].

Intra-operative parameters were obtained by reviewing the perioperative Patient Data Management Sheets (anesthesia records), including total duration of anesthesia, use of inhalational or total intravenous anesthesia and use of vasopressor drugs or antihypertensive drugs.

Hemodynamic variables

Hemodynamic profiles were reconstructed, using baseline (i.e. preoperative) blood pressure value (systolic, diastolic and mean pressure) as well as intraoperative blood pressure values with a five minute time interval, obtained by either invasive (if available) or non-invasive measurement.

Use of vasopressor drugs (i.e. use of norepinephrine continuous infusion or phenylephrine bolus injections) was recorded and initiated based on the anesthesiologist's assessment of the current hemodynamic situation. Conversely, pre- and intraoperative hypertension was treated with use of intravenous infusion of nicardipine.

If missing blood pressure values were present, the average blood pressure values just before and after the specific time point was calculated.

The study cohort was stratified into patients who experienced an intra-operative hypotensive event, defined as MAP < 65 mmHg and non-hypotensive patients, defined as MAP ≥ 65 mmHg. Relative hypotension (40% drop in MAP from baseline) was calculated. The time frame was from the start of the induction of the anesthesia to the reperfusion after recanalization.

Outcome measure

The primary outcome measure was good clinical outcome after three months (mRS 0, 1 or 2) [12]. Post-intervention reperfusion was scored using the Trombolysis in Cerebral Infarction (TICI) score, according to the interventional radiologists interpretation [13].

Statistical analysis

Data were expressed as median and interquartile range (IQR). The Wilcoxon test was used to compare continuous parameters between groups. The Chi Square test was used to compare categorical parameters between groups. Multivariable logistic regression analyses were conducted for mRS score at 90 days and mortality at 90 days. Important predictors of long-term outcome after stroke are age, NIHSS and pre-stroke mRS [14,15]. Therefore, these case-mix adjustments are included in the first model (table 4). Second, occurrence of hypotension was added in model (table 5) Lastly, all parameters were added in the multivariable model for mortality at 90 days (table 6). Parameter estimates with standard error, area under the curve (AUROC), R^2 and lack of fit (Hosmer-Lemeshow test) were reported. Results were considered significant if $p<0.05$. JMP, version 15.0.0 (SAS Institute Inc, Cary, NC, USA) was used for statistical analyses.

Results

Patient cohort (table 1)

Between January 2019 and July 2021, 98 patients were included. All patients underwent thrombectomy under general anesthesia. Median age was 76 (64-84) years and 53% of all patients were female (n=52).

Ninety-five percent of patients (n=94) suffered from hypotension defined according to the AHA guidelines (systolic blood pressure below 140mmHg) during procedure [1], figure 1.

Thirty-six percent of patients (n=35) were hypotensive (defined as mean arterial pressure below 65mmHg) at any given moment during the procedure, figure 2. Nine patients had hypotension longer than 15 minutes and 26 patients suffered from a brief period of hypotension (5-10 minutes). Proportion of patients suffering from dyslipidemia was higher in non-hypotensive patients compared to hypotensive patients 63% (n=40) vs. 40% (n=14), p=0.03. In total, 33% of all patients suffered from atrial fibrillation, this was comparable between groups (p=0.80). Eighty percent (n=78) had a pre-stroke mRS of 0 or 1, which was not different between groups (p=0.47). Median NIHSS on admission, history of arterial hypertension, ASPECTS score and Collateral score were similar between groups (p=0.14, p=0.69, p=0.84, p=0.87), table 1.

Thirty-seven percent received intravenous thrombolysis prior to mechanical thrombectomy. Proportion of patients who received thrombolysis was similar between non-hypotensive (40%, n=25) and hypotensive patients (31%, n=11). Door to needle time did not differ between the hypotensive and non-hypotensive groups, despite a 10 minute difference in median value (p=0.86). Door to groin time was also similar between both groups (p=0.84).

Intra-operative parameters (table 2)

Median door to revascularization time was 116 minutes (88-150) and duration of anesthesia was 70 minutes (49-102). These parameters did not differ between non-hypotensive vs. hypotensive group (p=0.10, p=0.85). Twenty-four percent of all patients (n=23) received nitrous oxide during thrombectomy and 65% received sevoflurane (n=63). Use of nitrous oxide was not different between groups (p=0.20). Proportion of patients receiving sevoflurane was higher in the non-hypotensive group vs. hypotensive group 73% (n=45) vs. 51% (n=18), p=0.04. Twenty-one percent received intra-operative antihypertensive drugs (n=20), which was similar between groups (p=0.61). Vasopressor use was lower in the non-hypotensive group vs. hypotensive group 63% (n=39) vs. 88% (n=30), p=0.008, table 2.

Functional outcome (table 3)

Eighty-five percent of all patients had successful revascularization (TICI 2C-3, n=82). Thirty-seven percent had a good functional state at 3 months (mRS ≤ 2, n=35). Proportion of mRS-score ≤ 2 was higher in non-hypotensive patients vs. hypotensive patients 44% (n=27) vs. 24% (n=8), p=0.04). Mortality at 3 months was less in non-hypotensive patients vs. hypotensive patients 21% (n=13) vs. 43% (n=15), p=0.02, table 3.

Long duration of hypotension (≥15min) (n=9) vs. brief period of hypotension (5-10min)(n=26) vs. no hypotension (n=63) showed no difference regarding functional outcome between groups, (p=0.18), Pearson test. Majority of patients with long duration of hypotension (n=8, 89%) had a mRS-score of 3-6 at 90 days.

Proportion mRS-score ≤ 2 at 3 months was similar between patients having systolic blood pressure ≥ 140 mmHg or not during MT (p=0.61).

Multivariable logistic regression analysis (table 4, 5 and 6)

Age and NIHSS on admission were independently associated with the mRS 3 months after thrombectomy, while the pre-stroke mRS was not ($p=0.02$, $p=0.003$, $p=0.75$ table 5). When occurrence of intra-operative hypotension (MAP<65mmHg) was added in the multivariable model, both age and NIHSS on admission remained, but also presence of hypotension was independently associated with functional outcome after stroke, while pre-stroke mRS was not ($p=0.03$, $p=0.003$, $p=0.03$, $p=0.82$, table 5). Age and NIHSS on admission were associated with 90-day mortality, while pre-stroke mRS and intra-operative presence of hypotension were not ($p=0.02$, $p=0.06$, $p=0.95$ and $p=0.12$, table 6).

Discussion

In this single center retrospective study cohort we investigated if there is an association between hypotension (MAP < 65mmHg) and neurological outcome as well as the type of anesthesia (Total Intravenous Anesthesia (TIVA) versus volatile agents) which could influence neurological outcome in patients undergoing mechanical thrombectomy under general anesthesia.

We observed an association between hypotension and worse neurological outcome (mRS 3-6) or mortality. This association remained robust in a multivariable model of mRS score at 90 days, but this was not present for mortality at 90 days. This result is in line with multiple other retrospective analyses, meaning tackling hypotension during thrombectomy may be crucial [16–20]. Moreover, despite using vasopressor therapy during MT, still thirty-six percent of patients were hypotensive (MAP < 65 mmHg) at any given moment. This means that hypotension may need to be treated and even prevented more aggressively.

In contrast, the association between BP and neurological outcome in patients undergoing endovascular treatment under general anaesthesia has already been investigated with studies claiming that no clear relation exists between BP control and neurologic outcome [21,22]. Some studies found an inverse relation between the use of norepinephrine and neurological outcome [21,23].

Fandler-Höfler et al. examined the influence of periprocedural blood pressure (BP), especially critical BP drops, on 3-month functional outcome in stroke patients undergoing mechanical thrombectomy under general anaesthesia. This revealed that a single mean arterial BP (MAP) drops below 60 mmHg are independently related to unfavorable 3-month outcome [24]. Low blood pressure peri-operatively during MT is clearly a very important risk factor for development of worse neurological outcome.

Current AHA guidelines for maintaining blood pressure during MT suggest a blood pressure below 180/105 mmHg and a systolic blood pressure maintained above 140 mmHg [1,25]. Despite the majority of patients in this study cohort suffered from hypotension (SAP<140 mmHg), overall long-term outcome after thrombectomy of this study cohort is comparable to that of other centers [26]. Also a drop of SAP<140 mmHg was not independently associated with poor functional outcome, as it is for the MAP<65 mmHg.

In the multicentric study of Germany, successful reperfusion (TICI 2b or higher) occurred in 83% of all patients, 37% of all patients had good functional outcome (mRS 0-2) after MT and mortality at 90 days was 29%. In this study cohort, successful reperfusion (TICI 2b or higher) was 92%, 37% of all patients had a mRS 0-2 after 90 days and mortality was 29%, which is similar to these findings [26].

It could be hypothesized that augmented systolic blood pressure improves neurological outcome because of improved collateral and penumbral blood flow [27]. Deng et al. investigated if systolic blood pressure augmentation (systolic pressure between 160-180mmHg) during MT for anterior large vessel occlusion improved neurological outcome. Sixty-two percent of the patients in the standard group (systolic pressure between 130-150mmHg) were functionally independent at 90 days compared to 56% of patients in the augmented group. This showed no significant difference in early neurological outcomes, nor mortality at 90 days, intra-operative complications and intracranial haemorrhage. This augmented systolic pressure will be investigated further in detail in the ongoing MASTERSTROKE (MAnagement of Systolic blood pressure during Thrombectomy by Endovascular Route for acute ischaemic STROKE) trial [28,29].

Performing MT under general anesthesia is now considered to be safe. It has been a matter of debate for a long time because worse neurological outcomes seemed to be associated with general anesthesia compared to conscious sedation [6]. One reason why these early observational studies showed a worse neurological outcome in the general anesthesia population may be because of poor blood pressure control leading to hemodynamic instability compared to conscious sedation [28]. Worse neurological outcome because of low blood pressure may be due to the hypothesis that penumbral perfusion is pressure dependent and thus requires a stable elevated blood pressure [17,30]. Another reason for this worse neurological outcome could be attributed to the fact that patients undergoing general anesthesia were biased by indication. Patients with increased stroke severity and poor clinical presentation were more likely to be treated under general anesthesia [30].

Recent research has shown that performing MT under general anesthesia leads to improved recanalization (TICI 2b or higher) rates (85%) compared to conscious sedation (75%) and leads to similar and improved functional recovery (40%) compared to conscious sedation (36%) [27,31]. In our study cohort, 92% of all patients had a TICI-score of 2B or higher.

More technical failure of thrombectomy was present in the conscious sedation group compared to general anesthesia (7% vs. 2%). Moreover, in this study cohort recanalization rate was 86% (TICI 2c or higher) and 37% of all patients had good neurological outcome at 3 months (mRS 0-2).

The anaesthetic agent of choice (TIVA or volatile anaesthetics) during MT under GA for stroke patients is not well known but might affect outcome. Higher brain tissue oxygen tension was reported with the use of volatile agents compared with TIVA [23]. The SIESTA and GOLIATH studies used intravenous propofol and showed an improved functional outcome at 3 months. The AnStroke study used volatile anesthetics and did not show an improved functional outcome at 3 months [8–10,32]. Standard use of either volatile agents or TIVA in mechanical thrombectomy for stroke is not clarified because of their different effects on cerebral perfusion. Potent volatile anesthetics such as sevoflurane or desflurane are direct cerebral vasodilators, inhibit autoregulation and induce a decrease in cerebral oxygen consumption. In low doses this leads to minimal increase in cerebral blood flow (CBF), at high doses, when maximal suppression of cerebral oxygen consumption occurred, vasodilatory effects lead to an increased CBF. Arterial carbon dioxide tension responsiveness remains intact with volatile agents such that hyperventilation is desirable for example during anesthesia for traumatic brain injury. Intravenous drugs such as propofol, etomidate or benzodiazepines decrease CBF but autoregulation and arterial carbon dioxide tension responsiveness remain intact [33]. Different cerebrovascular effects on the ischemic penumbra could influence neurological outcome in patients undergoing MT. Diprose et al. found an increased odds of functional independence at 3 months and a nonsignificant trend toward reduced mortality by using intravenous propofol in patients undergoing MT under general anaesthesia [32]. In contrast, in this study, proportion of sevoflurane-use was higher in the non-hypotensive group, compared to the hypotensive group. Moreover, since hypotension is such an important factor in long-term neurological outcome, sevoflurane might be preferred instead of TIVA during anaesthetic management of MT. However, further prospective investigation is warranted for the anaesthetic agent with least disadvantages during MT.

There are several limitations of this study. First, this is a single-center retrospective observational study which limits general extrapolation of these findings. However, since we did not exclude any patient, these patients reflect real-time data. Second, the small sample size limits the power of statistical analysis conducted. Third, the level of experience of the treating anesthesiologist was not included in the multivariable models. Moreover, the TICI score was assessed by the radiological interventionalist and not by an independent scoring system.

Conclusion

This single center retrospective study showed an independent association between hypotension, defined as MAP below 65mmHg at any given time during general anesthesia in

MT patients ~~and~~ with worse neurological outcome. Second, in this study, patients undergoing MT with general anesthesia by using volatile agents have a less hypotension compared to intravenous anesthesia.

Hypotension during mechanical thrombectomy may have to be avoided at all time. It is not clear if current practice of using TIVA during neurosurgery is applicable for mechanical thrombectomy. Prospective multicenter randomized controlled trials which compare TIVA and volatile agents are needed to define optimal treatment of patients with stroke undergoing mechanical thrombectomy under general anesthesia.

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Figure 1: Systolic arterial blood pressure (SAP) of patients during thrombectomy, stratified according to occurrence of hypotension (MAP<65mmHg) or not. SAP=140 is considered as the minimum blood pressure during thrombectomy, according to the AHA guidelines. *(BL=baseline)*

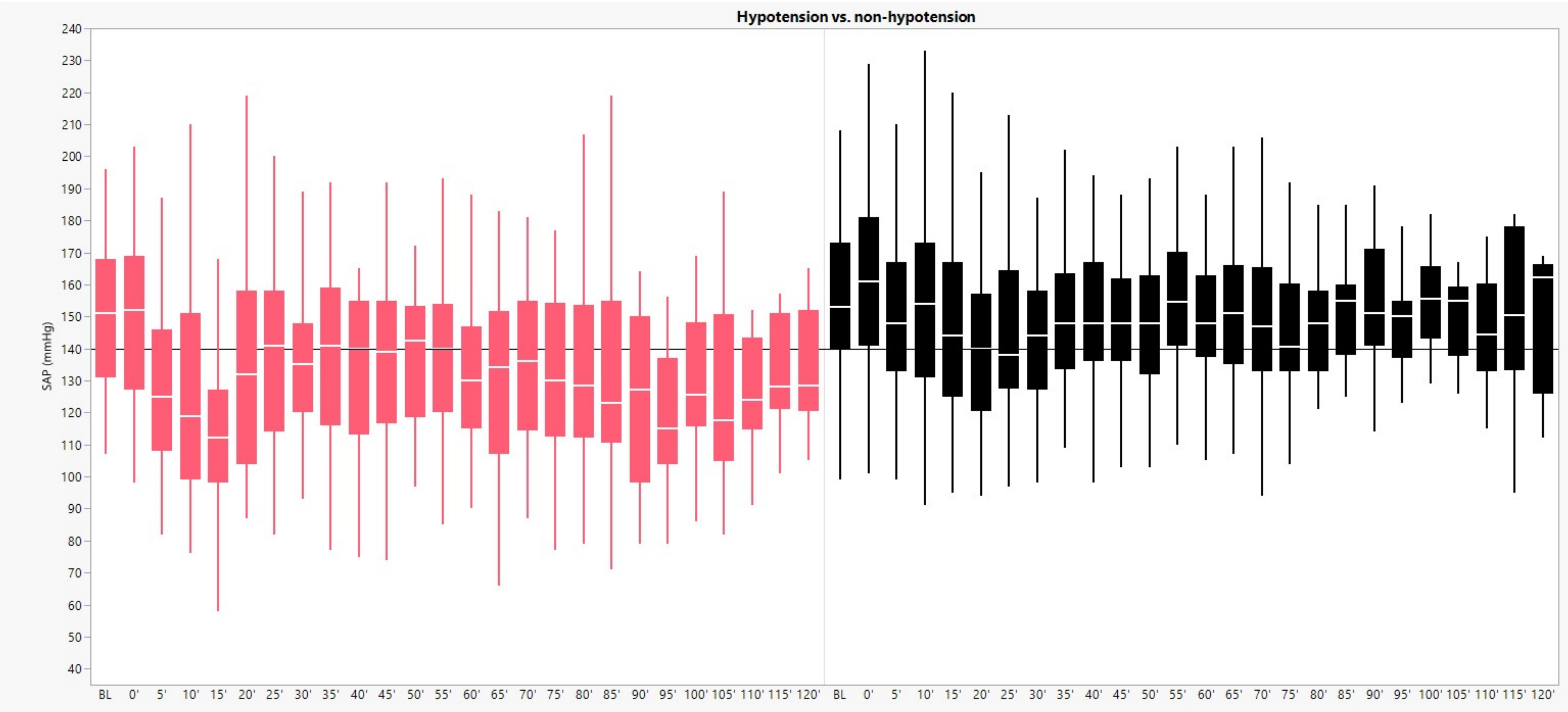

Figure 2: Mean arterial blood pressure (MAP) of patient during thrombectomy, stratified according to occurrence of hypotension (MAP<65mmHg) or not. *(BL=baseline)*

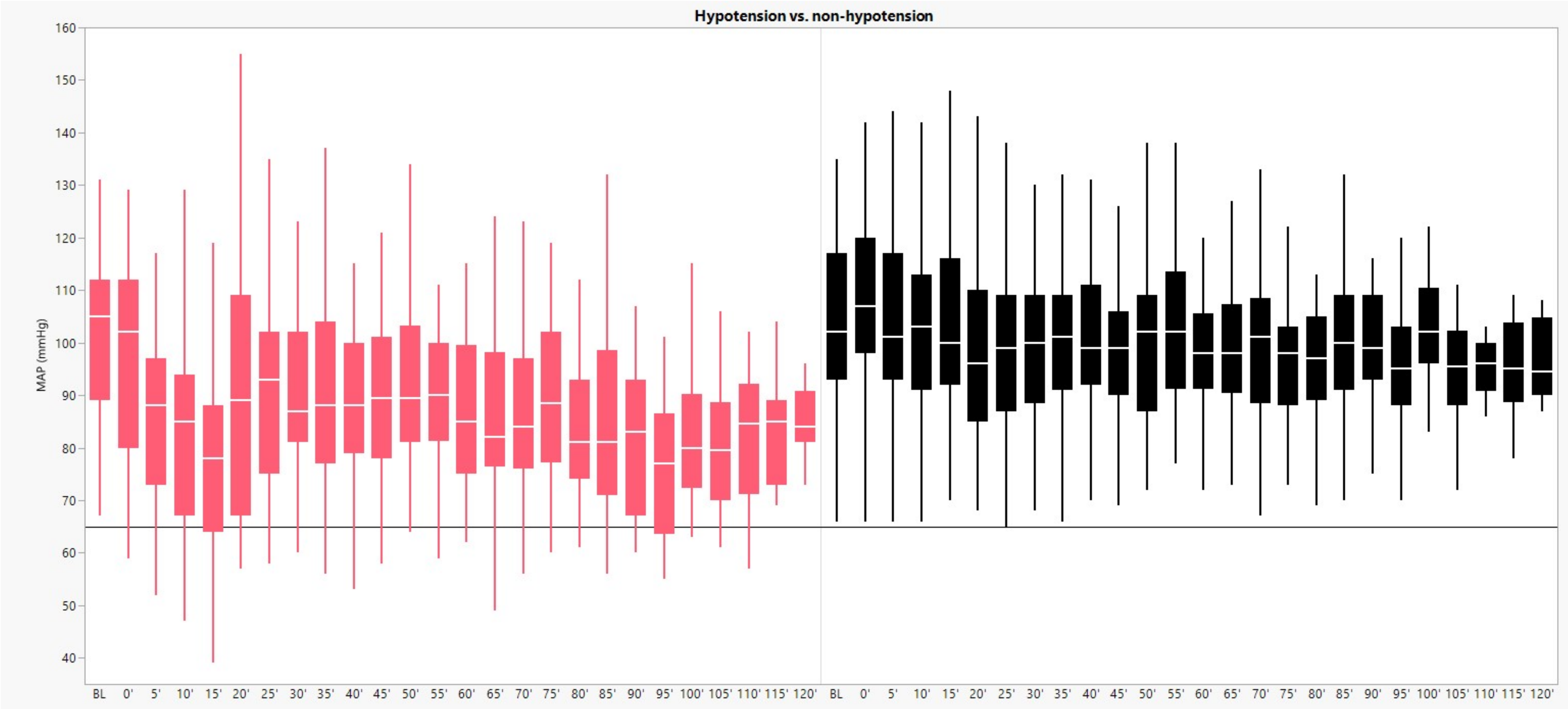

Table 1: Patient characteristics

	All patients (n=98)	**Non-hypotensive patients (n=63)**	**Hypotensive patients (n=35)**	**p-value**
Age, y*ears, median (IQR)*	76 (64-84)	72 (63-81)	82 (65-85)	0.06
Sex, *female, n (%)*	52 (53%)	35 (56%)	17 (49%)	0.51
Glycemia, *mg/dL, median (IQR)*	126 (108-162)	126 (106-148)	129 (109-171)	0.49
Number of patients with dyslipidemia, *n (%)*	54 (55%)	40 (63%)	14 (40%)	0.03
Number of patients with atrial fibrillation, *n (%)*	32 (33%)	20 (32%)	12 (34%)	0.80
History of arterial hypertension, *n (%)*	(n=97) 58 (60%)	(n=62) 38 (61%)	(n=35) 20 (57%)	0.69
Pre-stroke mRS, *n (%)* *0* *1* *2* *3* *4* *5*	 *56 (57%)* *22 (22%)* *10 (10%)* *5 (5%)* *2 (2%)* *3 (3%)*	 *38 (60%)* *16 (25%)* *5 (8%)* *2 (3%)* *1 (2%)* *1 (2%)*	 *18 (51%)* *6 (17%)* *5 (14%)* *3 (9%)* *1 (3%)* *2 (6%)*	0.47
NIHSS, *median (IQR)*	(n=97) 16 (12-20)	(n=62) 16 (11-20)	(n=35) 19 (13-21)	0.14
ASPECTS score, *median (IQR)*	(n=85) 9 (8-10)	(n=54) 9 (8-10)	(n=31) 9 (6-10)	0.84

Collateral score, *median (IQR)*	(n=41) 4 (3-5)	(n=26) 4 (3-5)	(n=15) 4 (2-5)	0.87
Thrombolysis, *n (%)*	36 (37%)	25 (40%)	11 (31%)	0.42
Door to needle time, *minutes, median (IQR)*	(n=34) 27 (16-44)	(n=22) 24 (16-42)	(n=12) 34 (15-46)	0.86

IQR=interquartile range, mRS=modified Rankin scale, NIHSS=National Institutes of Health Stroke Scale

Table 2: Parameters during anesthesia

	All patients (n=98)	**Non-hypotensive patients (n=63)**	**Hypotensive patients (n=35)**	**p-value**
Door to groin time, *minutes, median (IQR)*	(n=93) 81 (56-102)	(n=59) 81 (58-102)	(n=34) 79 (49-102)	0.84
Door to revascularization time, *minutes, median (IQR)*	(n=35) 116 (88-150)	(n=21) 130 (106-151)	(n=14) 98 (73-137)	0.10
Duration of anesthesia, *minutes, median (IQR)*	70 (49-102)	69 (51-93)	70 (45-116)	0.85
Number of patients who received nitrous oxide, *n (%)*	(n=94) 23 (24%)	(n=59) 17 (29%)	(n=35) 6 (17%)	0.20
Number of patients who received sevoflurane, *n (%)*	(n=97) 63 (65%)	(n=62) 45 (73%)	(n=35) 18 (51%)	**0.04**
Number of patients who received intra-operative antihypertensive drugs, *n (%)*	(n=96) 20 (21%)	(n=62) 14 (23%)	(n=34) 6 (18%)	0.61
Number of patients who received vasopressors during procedure, *n (%)*	(n=96) 69 (72%)	(n=62) 39 (63%)	(n=34) 30 (88%)	**0.008**

IQR=interquartile range

Table 3: Patient outcome

	All patients (n=98)	**Non-hypotensive patients (n=63)**	**Hypotensive patients (n=35)**	**p-value**
TICI-score, *n (%)*	(n=97)	(n=62)	(n=35)	
0	7 (7%)	4 (6%)	3 (9%)	
2B	8 (8%)	5 (8%)	3 (9%)	0.45
2C	20 (21%)	10 (16%)	10 (29%)	
3	62 (64%)	43 (69%)	19 (54%)	
Number of patients with mRS 0-2 at 3 months, *n (%)*	(n=95) 35 (37%)	(n=61) 27 (44%)	(n=34) 8 (24%)	**0.04**
Mortality at 3 months, *n (%)*	28 (29%)	13 (21%)	15 (43%)	**0.02**

TICI=Thrombolysis in cerebral infarction, mRS=modified Rankin scale

Table 4: Multivariable logistic regression analysis of mRS-score at 3 months with age, NIHSS on admission and pre-stroke mRS score

N=94	**Parameter estimate (standard error)**	**P-value**
- Age	-0.03 (0.01)	0.02
- NIHSS on admission	-0.09 (0.03)	0.003
- Pre- stroke mRS		0.75
- Pre- stroke mRS [1-0]	-0.13 (0.46)	
- Pre- stroke mRS [2-1]	-0.59 (0.70)	
- Pre- stroke mRS [3-2]	-0.17 (1.06)	
- Pre- stroke mRS [4-3]	0.78 (1.64)	
- Pre- stroke mRS [5-4]	-0.88 (1.75)	

NIHSS=National Institutes of Health Stroke Scale, mRS=modified Rankin scale

AUROC mRS1= 0.70, mRS2=0.73, mRS3=0.73, mRS4=0.75, mRS5=0.72, mRS6=0.73

R^2=0.06, lack of fit p=1.00

Table 5: Exploratory multivariable logistic regression analysis of mRS-score at 3 months with age, NIHSS on admission and pre-stroke mRS score and presence of hypotension (MAP<65mmHg)

N=94	**Parameter estimate (95% CI)**	**P-value**
- Age	-0.03 (0.01)	0.03
- NIHSS on admission	-0.09 (0.03)	0.003
- Pre- stroke mRS		0.82
- Pre- stroke mRS [1-0]	-0.25 (0.47)	
- Pre- stroke mRS [2-1]	-0.44 (0.71)	
- Pre- stroke mRS [3-2]	-0.14 (1.10)	
- Pre- stroke mRS [4-3]	0.83 (1.68)	
- Pre- stroke mRS [5-4]	-0.81 (1.77)	
- Intra-operative hypotension	0.88 (0.41)	0.03

NIHSS=National Institutes of Health Stroke Scale, mRS=modified Rankin scale

AUROC mRS1= 0.71, mRS2=0.77, mRS3=0.75, mRS4=0.77, mRS5=0.72, mRS6=0.75

R^2=0.08, lack of fit p=1.00

Table 6: Multivariable logistic regression analysis of mortality at 3 months with age, NIHSS on admission and pre-stroke mRS score and presence of hypotension (MAP<65mmHg)

N=97	**Parameter estimate (95% CI)**	**P-value**
- Age	-0.05 (0.02)	0.02
- NIHSS on admission	-0.07 (0.04)	0.06
- Pre- stroke mRS		0.95
- Pre- stroke mRS [1-0]	0.07 (0.64)	
- Pre- stroke mRS [2-1]	-0.53 (0.88)	
- Pre- stroke mRS [3-2]	-0.52 (1.36)	
- Pre- stroke mRS [4-3]	1.36 (1.91)	
- Pre- stroke mRS [5-4]	-0.25 (1.98)	
- Intra-operative hypotension	0.78 (0.51)	0.12

NIHSS=National Institutes of Health Stroke Scale, mRS=modified Rankin scale

AUROC mRS6= 0.77

R^2=0.15, lack of fit p=0.20