ORIGINAL RESEARCH

Prognostic Significance of Pulse Pressure Variability During Mechanical Thrombectomy in Acute Ischemic Stroke Patients

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***Background*—**Studies on the role of blood pressure (BP) variability specifically during mechanical thrombectomy (MT) are sparse and limited. Moreover, pulse pressure (PP) has not been considered as a potent hemodynamic parameter to describe BP variability during MT. We assessed the impact of PP variability on functional outcome in acute ischemic stroke patients with large vessel occlusion during MT.

***Methods and Results*—**Acute ischemic stroke patients presenting with large vessel occlusion from January 2012 to June 2016 were included. BP data during MT were prospectively collected in the ETIS (Endovascular Treatment in Ischemic Stroke) registry. Logistic regression models were used to assess the association between PP coefficients of variation and functional outcome at 3 months (modified Rankin Scale). Among the 343 included patients, PP variability was significantly associated with worse 3-month modified Rankin Scale in univariable (odds ratio [OR]=1.56, 95% confidence interval [CI]: 1.24–1.96 per 1-unit increase, *P*=0.0002) and multivariable ordinal logistic regression (adjusted OR=1.40, 95% CI: 1.09–1.79, *P*=0.008). PP variability was also associated with unfavorable outcome (modified Rankin Scale 3–6) in univariable (OR=1.53, 95% CI: 1.17–2.01, *P*=0.002) and multivariable analysis (adjusted OR=1.42, 95% CI: 1.02–1.98, *P*=0.04). There was an association between PP variability and 3-month all-cause mortality in univariable analysis (OR= 1.37, 95% CI: 1.01–1.85 per 1-unit increase of the coefficient of variation of the PP, *P*=0.04), which did not remain significant after adjustment for potential confounders.

***Conclusions*—**PP variability during MT is an independent predictor of worse clinical outcome in acute ischemic stroke patients. These findings support the need for a close monitoring of BP variability during MT. Whether pharmacological interventions aiming at reducing BP variability during MT could impact functional outcome needs to be determined. **(*J Am Heart Assoc*. 2018;7: e009378. DOI: 10.1161/JAHA.118.009378.)**

Key Words: blood pressure • blood pressure measurement/monitoring • ischemic stroke • pulse pressure • thrombectomy

Determining the optimal peri-procedural management of blood pressure (BP) during mechanical thrombectomy (MT) is of significant importance since high BP is a frequent condition in acute ischemic stroke (AIS) and known to be associated with worse functional outcome and mortality.[1] Recent evidence supports the impact of baseline systolic blood pressure (SBP) on mortality and functional outcome at 3 months in MT treated patients,[2,3] but data on the role of BP variability specifically during the procedure are sparse and limited. The definition of BP variability often differs across

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Clinical Perspective

What Is New?

- In acute ischemic stroke patients presenting with large vessel occlusion, pulse pressure variability during mechanical thrombectomy is associated with worse clinical outcome at 3 months.

What Are the Clinical Implications?

- Hemodynamic monitoring during mechanical thrombectomy is critical.
- Randomized controlled trials are needed to evaluate the benefit of blood pressure control if any.

studies and the main hemodynamic parameters measured are SBP and mean arterial pressure.[4] Moreover, BP variability was mainly assessed within the first 24 hours and not before recanalization occurs, period in which BP variability might highly influence the penumbra's survival and clinical outcome. Although recent guidelines recommend avoiding excessive BP drops during MT,[5] there is currently no evidence suggesting an association between per-procedural BP variability and functional outcome. In this context, pulse pressure (PP) may be a better parameter than SBP to describe BP variability because it describes more accurately the pulsatile component of BP.[6] PP in the setting of AIS has been described to be associated with poor stroke outcome at 3 months,[7] but evidences are lacking in the setting of acute reperfusion therapies in patients experiencing large vessel occlusion (LVO). We aimed to assess the association between PP variability during MT and functional outcome at 3 months.

Methods

According to the Transparency and Openness (TOP) Guidelines, the data, analytic methods, and study materials will be made available from the corresponding author upon reasonable request, to other researchers for purposes of reproducing the results or replicating the procedure.

Population

The ETIS (Endovascular Treatment in Ischemic Stroke) registry is an ongoing French multicenter prospectively collected database from 3 Comprehensive Stroke Centers (Rothschild Foundation, Foch Hospital, and Pierre Wertheimer Hospital) including AIS patients with LVO and treated with MT. For this study, we only used ETIS data of 1 center (Rothschild Foundation) since per-procedural BP measures were lacking in the remaining centers. Patients included between January 2012 and June 2016 were eligible for the present study if they (1) had an AIS proven on cerebral imaging (MRI or CT) with documented LVO of the anterior or posterior circulation; (2) were treated by MT within 8 hours of stroke onset for anterior circulation, 12 hours for posterior circulation; and (3) had available BP data during MT. Exclusion criteria were as follows: lack of persistent large vessel occlusion on the baseline Digital Subtraction Angiography; absence of functional outcome assessment (modified Rankin Scale-mRS-) at 3 months. All patients had a CT or MRI 24 hours after treatment onset to assess hemorrhagic complications. Successful recanalization was defined as a modified Thrombolysis in Cerebral Infarction (mTICI) score of IIb or III.

Pre-treatment National Institutes of Health Stroke Scale was assessed by stroke neurologists and functional outcome at 3 months (mRS score) via face-to-face or phone interviews by stroke neurologists or research nurses (the mRS is a 7-point scale ranging from 0 (no symptoms) to 6 (death), a score of $\leq$2 indicates functional independence).

The local ethics committee and French Data Protection Agency approved the use of patient data for this research protocol. In accordance with the French legislation, informed consent was not needed from patients because this study implied only analysis of anonymized data collected prospectively as part of routine clinical care.

Clinical Outcomes

The primary end point was worse functional outcome, defined as a shift in the direction of a higher score on the mRS at 3 months.[8] Secondary end points included unfavorable outcome (3-month mRS score 3–6), mortality at 3 months and symptomatic intracranial hemorrhage (sICH). sICH was defined as blood at any site in the brain, causing an increase of $\geq$4 points in the National Institutes of Health Stroke Scale (NIHSS) score within 24 hours.[9]

Blood Pressure Variability

BP was non-invasively measured by a validated BP monitor and prospectively recorded every 10 minutes for patients with conscious sedation and every 2 to 5 minutes in case of general anesthesia. The first BP measurement during MT was at the patient's arrival in the catheter laboratory, to take into account any fluctuation attributable to the induction of general anesthesia, and the last measure was 10 to 15 minutes after recanalization. BP at the time of recanalization was also collected.

BP was documented using SBP, diastolic BP, and PP (ie SBP minus diastolic BP) and was managed at the discretion of both the anesthesiologist and the interventionist according to current guidelines.[10] Antihypertensive treatments used were either nicardipine or urapidil, and norepinephrine was

the drug of choice to treat any BP drops.[5] Since no randomized control trial have assessed the efficacy of a treatment to reduce BP variability during MT, no effective measure was prescribed to reduce BP variability.

Blood pressure variability was assessed by calculating the coefficient of variation of the PP and SBP for each patient by dividing the standard deviation of PP or SBP by the mean of the PP or SBP, respectively, as previously published in visit-to-visit BP variability studies.[11]

Statistical Analysis

Quantitative variables were described as mean±SD in the case of normal distribution or median (interquartile range) otherwise. Categorical variables were expressed as number (percentage). Associations between baseline variables and outcomes (3-month mRS, mortality or sICH) were assessed by calculations of crude and adjusted odds ratios (ORs) in logistic regression models. Baseline variables associated with the dependent variable at a level of $P<0.10$ in univariable analysis were considered for inclusion into multivariable models, taking into account potential multi-collinearity. For the analysis of the primary end point, an ordinal logistic regression (shift analysis of the mRS, with score 5 and 6 collapsed into a single group[12]) was performed, after checking that the assumption of proportional odds was fulfilled.[13] We non-parametrically examined the possibly non-linear relationship between each BP-derived variable (PP before MT[2]; mean PP during MT; coefficient of variability of the PP during MT) and each outcome with restricted cubic splines with 3 knots, corresponding to the 5th, 50th, and 95th percentiles of the BP-derived variable. Tests for non-linearity used the likelihood ratio test, comparing the model with only the linear term to the model with the linear and the cubic spline terms.[14] Using interaction terms (product terms) in logistic models, we also assessed whether prespecified variables (successful recanalisation, general anesthesia, use of BP-modifying drugs during MT) modified the association between PP variability and functional outcome. Statistical testing was done at the 2-tailed alpha level of 0.05. Statistical analysis was performed using SAS 9.4 (SAS Institute, Inc, Cary, NC).

Results

Baseline characteristics, revascularization status and clinical outcomes of the 343 included patients are reported in Table 1. Successful recanalization occurred in 82.2% (n=282) patients and median mRS at 3 months was 3 (interquartile range: 1–5). Unfavorable outcome was observed in 56.9% (n=195) patients, all-cause mortality at 90 days was 19.8% (n=68), and sICH occurred in 7.8% (n=23) patients. Median number of BP measures was 13 (interquartile range: 11–17) and all patients had at least 5 BP measures during MT.

In univariable analysis, variables significantly associated with worse 3-month mRS (shift analysis, Table 2) were age, hypertension, diabetes mellitus, pre-stroke mRS, baseline NIHSS score, use of general anesthesia, and successful recanalization.

Table 1. Population Characteristics (n=343)

Baseline characteristics	
Age, y, mean±SD	66.9±15.2
Men	178 (51.9)
Hypertension*	202 (59.2)
Diabetes mellitus*	58 (17.0)
Current smoking*	62 (18.2)
Pre-stroke mRS >1*	28 (8.3)
NIHSS before MT, median (IQR)*	16 (11–20)
Mechanical thrombectomy	
Intravenous thrombolysis before MT	220 (64.1)
Site of vessel occlusion	
Isolated MCA	202 (58.9)
ICA with or without MCA	122 (35.6)
Vertebrobasilar or other location	19 (5.5)
General anesthesia	72 (21.0)
Onset to groin puncture time, min, median (IQR)*	254 (210–325)
Successful recanalization	282 (82.2)
Blood pressure	
PP before MT, mean±SD, mm Hg	69.4±23.5
SBP before MT, mean±SD, mm Hg	150.8±25.7
DBP before MT, mean±SD, mm Hg	81.4±18.0
Number of BP measurements during MT, median (IQR)	13 (10–17)
Mean PP during MT, mean±SD, mm Hg	70.2±15.5
Mean SBP during MT, mean±SD, mm Hg	144.0±17.6
Mean DBP during MT, mean±SD, mm Hg	73.7±10.6
Outcomes	
3-mo mRS, median (IQR)	3 (1–5)
3-mo mRS >2	195 (56.9)
All-cause mortality at 3 mo	68 (19.8)
sICH (ECASS-2 definition)*	23 (7.8)

Numbers in parentheses are percentages, unless indicated. DBP indicates diastolic blood pressure; ECASS, European Cooperative Acute Stroke Study; ICA, internal carotid artery; IQR, interquartile range; MCA, middle cerebral artery; mRS, Modified Rankin scale; MT, mechanical thrombectomy; NIHSS, National Institutes of Health Stroke Scale; PP, pulse pressure; and SBP, systolic blood pressure.

*Missing data for the following variables: hypertension (n=2), diabetes mellitus (n=2), current smoking (n=2), pre-stroke mRS (n=5), NIHSS (n=8), onset-to-groin puncture time (n=7), sICH (n=47).

Table 2. Association Between Clinical or Radiological Variables and Worse Functional Outcome (Univariable Analysis, Ordinal Logistic Regression)

	OR (95% CI)	*P* Value
Baseline characteristics		
Age, per 10-y increase	1.36 (1.20–1.55)	<0.0001
Men	1.07 (0.74–1.56)	0.72
Hypertension*	1.55 (1.06–2.28)	0.02
Diabetes mellitus*	1.73 (1.04–2.87)	0.03
Current smoking*	1.15 (0.70–1.86)	0.59
Pre-stroke mRS, per 1-point increase*	1.85 (1.38–2.49)	<0.0001
NIHSS before MT, per 1-point increase*	1.13 (1.10–1.17)	<0.0001
Mechanical thrombectomy		
Intravenous thrombolysis before MT	0.68 (0.46–1.01)	0.06
Site of vessel occlusion		
Isolated MCA	1.00 (Reference)	0.29
ICA with or without MCA	1.31 (0.88–1.95)	
Vertebrobasilar or other location	0.77 (0.34–1.77)	
General anesthesia	2.26 (1.41–3.62)	0.0007
Onset to groin puncture time, per 30-min increase*	1.00 (0.95–1.05)	0.96
Successful recanalization	0.38 (0.23–0.63)	0.0002
Blood pressure		
PP before MT, per 10-mm Hg increase	1.00 (0.93–1.09)	0.94
Mean PP during MT	0.99 (0.87–1.11)	0.82
Coefficient of variation of the PP	1.56 (1.24–1.96)	0.0002

Numbers in parentheses are percentages, unless indicated. CI indicates confidence interval; DBP, diastolic blood pressure; ICA, internal carotid artery; IQR, interquartile range; MCA, middle cerebral artery; mRS, Modified Rankin scale; MT, mechanical thrombectomy; NIHSS, National Institutes of Health Stroke Scale; PP, pulse pressure; SBP, systolic blood pressure.
*Missing data for the following variables: hypertension (n=2), diabetes mellitus (n=2), current smoking (n=2), pre-stroke mRS (n=5), NIHSS (n=8); onset-to-groin puncture time (n=7).

Table 3. Association Between Pulse Pressure (PP) Variability and Worse 3-Month mRS (Multivariable Ordinal Logistic Regression)

Variable	Adjusted Odds Ratio (95% CI)	*P* Value
Coefficient of variation of PP, per 1-unit increase	1.40 (1.09–1.79)	0.008
Age, per 1-y increase	1.03 (1.02–1.05)	<0.0001
Hypertension	1.21 (0.77–1.90)	0.42
Diabetes mellitus	1.77 (1.02–3.08)	0.04
Pre-stroke mRS, per 1-point increase	1.73 (1.26–2.38)	0.0008
Baseline NIHSS score, per 1-point increase	1.11 (1.07–1.15)	<0.0001
General anesthesia	2.48 (1.45–4.26)	0.0009
Intravenous thrombolysis	0.56 (0.37–0.86)	<0.0001
Successful recanalization	0.32 (0.18–0.55)	0.008

All variable included in the model are presented in the table. CI indicates confidence interval.

The coefficient of variation of PP was significantly associated with worse 3-month mRS in univariable shift analysis (OR=1.56, 95% confidence interval (CI): 1.24–1.96 per 1-unit increase, *P*=0.0002, Table 2) and after adjustment for age, hypertension, diabetes mellitus, pre-stroke mRS, baseline NIHSS score, general anesthesia, intravenous thrombolysis, and recanalization (OR=1.40, 95% CI: 1.09–1.79, *P*=0.008, Table 3). Further adjustment for PP before thrombectomy yielded similar results (data not shown). There was also a significant association between PP variability and 3-month unfavorable outcome (mRS 3–6) in univariable analysis (OR=1.53, 95% CI: 1.17–2.01, *P*=0.002, Table 4) and after adjustment for the above-mentioned variables (adjusted OR=1.42, 95% CI: 1.02–1.98, *P*=0.04, Table 5). Neither successful recanalization, nor general anesthesia, nor use of BP-modifying drugs were effect-modifiers of the association between PP variability and functional outcome. There was an association between PP variability and 3-month all-cause mortality in univariable analysis (OR=1.37, 95% CI: 1.01–1.85 per 1-unit increase of the coefficient of variation of the PP, *P*=0.04), which did not remain significant after adjustment for potential confounders, namely age, diabetes mellitus, pre-stroke mRS, NIHSS score, general anesthesia, and successful revascularization (adjusted OR=1.19, 95% CI: 0.85–1.66 per 1-unit increase, *P*=0.32). There was no association between PP variability and sICH in univariable (OR=0.93, 95% CI: 0.55–1.58, *P*=0.79) or multivariable analysis (data not shown).

The coefficient of variation of SBP was significantly associated with worse 3-month mRS in univariable shift analysis (OR=2.16, 95% CI: 1.50–3.10 per 1-unit increase, *P*<0.0001) and after adjustment for age, hypertension, diabetes mellitus, pre-stroke mRS, baseline NIHSS score, general anesthesia, recanalization, and intravenous thrombolysis (OR=1.62, 95% CI: 1.07–2.45, *P*=0.02). The association between SBP variability and 3-month unfavorable outcome (mRS 3–6) was significant in univariable analysis (OR=1.83, 95% CI: 1.20–2.80, *P*=0.005) but did not reach statistical significance after adjustment for the above-mentioned variables (adjusted OR=1.40, 95% CI: 0.81–2.42, *P*=0.23). Neither successful recanalization, nor general anesthesia, nor use of BP-modifying drugs were effect-modifiers of the association between SBP variability and functional outcome. SBP variability was significantly associated with 3-month mortality in univariable analysis (OR=1.71, 95% CI: 1.07–2.74, *P*=0.02) but did not

Table 4. Association Between Clinical or Radiological Variables and Unfavorable Functional Outcome (3-Month mRS: 3–6, Univariable Analysis)

	OR (95% CI)	*P* Value
Baseline characteristics		
Age, per 10-y increase	1.44 (1.24–1.67)	<0.0001
Men	0.90 (0.59–1.38)	0.63
Hypertension*	1.57 (1.01–2.43)	0.04
Diabetes mellitus*	1.55 (0.86–2.79)	0.15
Current smoking*	1.15 (0.66–2.01)	0.62
Pre-stroke mRS, per 1-point increase*	1.61 (1.12–2.31)	0.01
NIHSS before MT, per 1-point increase*	1.14 (1.10–1.19)	<0.0001
Mechanical thrombectomy		
Intravenous thrombolysis before MT	0.66 (0.42–1.03)	0.07
Site of vessel occlusion		
Isolated MCA	1.00 (Reference)	0.68
ICA with or without MCA	1.05 (0.67–1.66)	
Vertebrobasilar or other location	0.68 (0.27–1.75)	
General anesthesia	1.82 (1.05–3.16)	0.03
Onset to groin puncture time, per 30-min increase*	1.04 (0.98–1.10)	0.24
Successful recanalization	0.26 (0.13–0.52)	0.0001
Blood pressure		
PP before MT, per 10-mm Hg increase	1.05 (0.95–1.15)	0.35
Mean PP during MT, per 10-mm Hg increase	1.06 (0.92–1.22)	0.42
Coefficient of variation of the PP, per 1-unit increase	1.53 (1.17–2.01)	0.002

Numbers in parentheses are percentages, unless indicated. CI indicates confidence interval; DBP, diastolic blood pressure; ICA, internal carotid artery; IQR, interquartile range; MCA, middle cerebral artery; mRS, Modified Rankin scale; MT, mechanical thrombectomy; NIHSS, National Institutes of Health Stroke Scale; PP, pulse pressure; SBP, systolic blood pressure.
*Missing data for the following variables: hypertension (n=2), diabetes mellitus (n=2), current smoking (n=2), pre-stroke mRS (n=5), NIHSS (n=8), onset-to-groin puncture time (n=7).

reach statistical significance after adjustment for the above-mentioned variables (adjusted OR=1.28, 95% CI: 0.74–2.24, *P*=0.38). SBP variability was not independently associated with sICH in univariable (OR=1.23, 95% CI: 0.58–2.63, *P*=0.59) and multivariable analysis (OR=1.61, 95% CI: 0.60–4.31, *P*=0.34).

Discussion

We observed that PP variability, more than SBP variability, was associated with worse functional outcome in MT-treated AIS patients but not with mortality or sICH. The association of PP variability with functional outcome persisted after adjustment for anesthesia and reperfusion reinforcing the assumption that PP is per se a relevant predictor of stroke prognosis during MT.

Table 5. Association Between PP Variability and Unfavorable Outcome at 3-Month (mRS 3–6, Multivariable Binary Logistic Regression)

Variable	Adjusted Odds Ratio (95% CI)	*P* Value
Coefficient of variation of PP, per 1-unit increase	1.42 (1.02–1.98)	0.04
Age, per 1-y increase	1.04 (1.02–1.06)	<0.0001
Hypertension	1.19 (0.66–2.14)	0.56
Diabetes mellitus	1.83 (0.87–3.86)	0.11
Pre-stroke mRS, per 1-point increase	1.51 (0.98–2.33)	0.06
Baseline NIHSS score, per 1-point increase	1.14 (1.08–1.19)	<0.0001
General anesthesia	1.97 (0.97–4.01)	0.06
Intravenous thrombolysis	0.47 (0.27–0.83)	0.009
Successful recanalization	0.20 (0.09–0.44)	<0.0001

All variables included in the model are presented in the table. mRS indicates Modified Rankin scale; NIHSS, National Institutes of Health Stroke Scale; PP, pulse pressure.

In the setting of LVO patients treated with intravenous thrombolysis, BP variability was shown to be associated with Diffusion Weighted Imaging lesion growth and 90-day outcome, especially in non-recanalizers.[15] By contrast, we did not find an interaction with recanalization status, which might partly be explained by the modest number of BP collected after recanalization. In MT treated-patients, the issue of blood pressure variability has mainly been studied with regard to BP drops. A ≥10% mean arterial pressure drop from baseline appears to be strongly associated with poor outcome in AIS patients who recanalized after MT.[16] In MT-treated patients under general anesthesia, a fall >40% in mean arterial BP was an independent predictor for poor neurological outcome.[17] We did not observe any interaction between PP variability and functional outcome with general anesthesia, highlighting the complex pathophysiology of BP variability during the acute phase. This probably results from the standard of care in our institution, where the anesthesiologists anticipate BP drops in the setting of general anesthesia induction, with the systematical administration of vasopressors. This hypothesis is illustrated in a recent randomized trial in which the volume of infarct growth among patients treated under general anesthesia or conscious sedation was not statistically different and outcomes at 3 months were better in the general anesthesia group.[18] In this study, when mean arterial pressure dropped, its duration was not significantly longer for conscious sedation in comparison to general anesthesia patients.

Two different protocols were used to record blood pressure values with a closer one for general anesthesia: this difference could have led to an overestimation of PP variability. However, and as it was stated before, we did not find any interaction in the relationship between favorable outcome and blood pressure variability with the use of general anesthesia.

PP is a frequently used BP parameter in hypertension and acute coronary syndrome studies.[19,20] Recently, PP was found to be a stronger predictor of stroke and other major vascular events than common BP parameter (ie SBP, mean arterial pressure).[21] Affected by left ventricular ejection fraction, arterial stiffness, early pulse wave reduction and pulse rate, PP better represents the pulsatile and dynamic component of BP and therefore its variability,[22] making it a suitable candidate to monitor intracranial hemodynamics in the setting of AIS. PP variability was associated with functional outcome either in shift analysis and when mRS was dichotomized, whereas SBP variability was only associated with functional outcome in shift analysis. The mean PP before MT was high (69.4±23.5 mm Hg) in comparison with a moderately elevated mean SBP at admission (150.8±25.7 mm Hg).[6,7,20,23] This clearly describes the major arterial stiffness in this typical population of AIS patients more than an isolated systolic hypertensive response, which might explain the stronger relationship we found with PP variability and functional outcome. In addition, recent evidences suggested that arterial stiffness was associated with cerebrovascular resistance in the elderly[24] and that an increase in cerebrovascular resistance affect dynamic cerebral pressure flow relations in the brain.[25] Being a surrogate marker of arterial stiffness, PP may be a more integrative hemodynamic parameter than SBP to describe cerebrovascular resistance and hence BP variability. More studies are needed to confirm this hypothesis.

Other markers of arterial stiffness, such as the arterial stiffness index, have been shown to be associated with worse clinical outcomes. In a recent study, higher values of arterial stiffness index and PP were associated with poor intracranial collaterals in AIS patients with LVO.[26,27] Collateral scoring was not performed in the present study but further studies are needed to address the PP and arterial stiffness markers relevance for collateral functionality prediction and assessment in the setting of the acute phase.

We did not find any independent association between BP variability and sICH as it was previously published for intravenous thrombolysis.[28–30] Each patient in the present study underwent MT with a high rate of successful recanalization: 82.2%. The effect of BP variability on sICH might have been minimized thanks to successful recanalization.[31] Furthermore, BP variability was assessed only during MT and we did not assess BP variability after MT, a period in which BP variability might be associated with sICH.

An extensive literature of BP control trials in the acute phase never showed any advantage of BP lowering.[32–36] However, these studies included intravenous tissue plasminogen activator (t-PA)-treated patients, where the arterial status was not systematically monitored during the reperfusion therapy. As a consequence, the absence or presence of LVO and recanalization rates were not known. We may anticipate different impact of BP lowering therapies in the presence or absence of persistent intracranial occluded arteries. In the new era of MT, new studies are needed to test the effectiveness of BP reduction in the acute phase in selected patients (eg, in recanalized patients).

We must acknowledge some limitations to our study. Firstly, even though patients were included in a prospective registry, a selection bias cannot be ruled out. However, baseline characteristics of included patients were similar to those of randomized trials.[37] Secondly, we included anterior and posterior circulation strokes, essentially to have a pragmatic approach of stroke management. But BP pathophysiology and optimal management could strongly differ between anterior and posterior circulation strokes and hence limit the generalizability of our findings. Thirdly, the absence of association between BP variability and unfavorable functional outcomes (mRS 3–6) for SBP variability could be because of the small sample of our study. Further studies with larger sample size are needed to confirm those results. Fourth, although PP was measured in peripheral and might not strictly reflect central arterial stiffness, in elderly patients (as it was the case in this study), peripheral-central PP discrepancies tend to decrease because of a higher degree of central arterial stiffness.[38]

Finally, we did not find any interaction between the use of antihypertensive drugs with the association between PP variability and functional outcome. This result suggests that treatments prescribed to treat high BP do not act specifically on BP variability in the acute phase. The latter point contrasts with secondary prevention evidences, where BP variability is decreased with calcium-channel blockers in comparison to beta-blockers.[39] Several explanations may highlight those discrepancies: the interval between every BP measure was extremely shorter (ie procedure time) in our study as compared with the period of measure in Rothwell et al study. Finally, treatments were strictly given intravenously in our study. Therefore, in the acute phase, BP variability might be considered as a risk marker but further studies are needed to assess if any pharmacological interventions during MT could improve functional outcome.

In conclusion, we observed that PP variability during MT was independently associated with worse clinical outcome in AIS patients. These findings emphasize the need for a close monitoring of BP. Future guidelines on BP management during MT should take into account not only SBP threshold but also BP variability.

Appendix

The Endovascular Treatment in Ischemic Stroke–ETIS-(ETIS) Research Investigators: Fondation Ophtalmologique A. de Rothschild—Simon Escalard, MD; Michel Piotin, MD, PhD; Jean-Philippe Desilles, MD; Hocine Redjem, MD; Gabriele Ciccio, MD; Stanislas Smajda, MD; Mikael Mazighi, MD, PhD; Raphaël Blanc, MD; Robert Fahed, MD; Mikael Obadia, MD; Candice Sabben, MD.

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Disclosures

None.

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