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Clinical and Imaging Markers Associated With Hemorrhagic Transformation in Patients With Acute Ischemic Stroke

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Background and Purpose—Hemorrhagic transformation (HT) after acute ischemic stroke may cause severe neurological deterioration and affects functional outcome. Identifying patients most likely to suffer from this complication could potentially be used for future treatment selection. Reperfusion after endovascular therapy could be associated with different risk factors for HT than intravenous thrombolytics as these treatments largely differ. In this study, we aimed to identify clinical and imaging markers that are associated with HT subtypes in the MR CLEAN (Multicenter Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands) population.

Methods—In this post hoc analysis, all patients with follow-up imaging were included. HT was classified according to ECASS II (European Cooperative Acute Stroke Study). Variables with an association of P<0.1 were included in the multivariable logistic regression to identify clinical and radiological variables associated with petechial hemorrhagic infarction, parenchymal hematoma (PH), and symptomatic intracranial hemorrhage.

Results—Of the 478 out of 501 included patients in this subanalysis, 46% had HT (n=222). Of these, 66% had hemorrhagic infarction (n=147) and 34% PH (n=75). Symptomatic intracranial hemorrhage was observed in 7.3% (n=35) of all patients. Baseline National Institutes of Health Stroke Scale (odds ratio [OR], 1.05,95% CI, 1.01–1.09 per point) and absent/poor collaterals (OR, 1.90; 95% CI, 1.05–3.42) were significantly associated with hemorrhagic infarction. Increased systolic blood pressure (OR, 1.17; 95% CI, 1.05–1.31 per 10 mm Hg) and atrial fibrillation (OR, 1.94; 95% CI, 1.08–3.48) were associated with PH. Increased systolic blood pressure (OR, 1.28; 95% CI, 1.12–1.48) and antiplatelet use (OR, 2.6; 95% CI, 1.08–6.3) were associated with symptomatic intracranial hemorrhage.

Conclusions—Clinical and imaging stroke severity parameters were associated with HT, both in hemorrhagic infarction and PH, whereas baseline patients characteristics like systolic blood pressure, atrial fibrillation, and antiplatelet use were only associated with PH or symptomatic intracranial hemorrhage.

Clinical Trial Registration—URL: http://www.controlled-trials.com. Unique identifier: ISRCTN10888758. (Stroke. 2019;50:2037-2043. DOI: 10.1161/STROKEAHA.118.024255.)

Key Words: atrial fibrillation ■ blood pressure ■ infarction ■ intracranial hemorrhages ■ reperfusion ■ risk factors ■ stroke
Various risk factors associated with the occurrence of HT have been identified. These include: treatment with thrombolytic agents, age, hyperglycemia, hypertension, use of antiplatelet agents, large infarct size, early ischemic changes on computed tomography (CT), and cholesterol level. Most studies have examined risk factors for HT after treatment with intravenous thrombolysis (IVT). Recently, endovascular therapy (EVT) has become part of usual care for patients with acute ischemic stroke due to intracranial large vessel occlusions. It is not clear whether risk factors for HT differ after treatment with EVT. By determining factors that contribute to the development of HT, we may be able to identify patients at risk for developing HT and alter treatment to decrease this risk.

In this study, we aimed to identify clinical and imaging markers that are associated with the occurrence of HI, PH, and sICH in the MR CLEAN study (Multicenter Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands). In addition, we explored whether the association of these characteristics would differ per treatment group.

Methods

Anonymized trial data and analytic methods that support our study findings are available from the principal investigator (Email: mrclean@erasusmc.nl) on reasonable request.

Study Design

Data was obtained from MR CLEAN, a prospective multicenter randomized trial assessing the safety and effect of additional EVT compared with usual care only. Acute ischemic stroke patients with a proximal intracranial occlusion who could be treated with EVT within 6 hours of stroke onset were included for randomization. Patients who endured a previous stroke within 6 weeks before stroke onset were excluded, as were patients with a blood pressure exceeding 185 out of 110 mm Hg before start of treatment. Additionally, patients with a history of intracranial hemorrhage were specifically excluded for intraarterial treatment with alteplase, but not for EVT. More specific inclusion and exclusion criteria can be found in the MR CLEAN study protocol. A central medical ethics committee and the research boards of all participating centers accepted the MR CLEAN trial. From all patients or legal representatives, written informed consent was acquired.

To identify HT on radiological images, follow-up CT scans, acquired at ≤5 days after inclusion, were assessed. When follow-up scans at 5 days were not available, 24-hour follow-up CT scans were examined. HT was identified and classified according to the ECASS II (European Cooperative Acute Stroke Study) classification: HI was defined as small petechiae along the margins of the infarct; HI2 as confluent petechiae within the infarcted area but no space-occupying effect; PH1 as blood clots in 30% of the infarcted area with slight space-occupying effect; and PH2 as blood clots in 30% of the infarcted area with a substantial space-occupying effect. Any intracranial hemorrhage visible on CT with concurrent neurological deterioration (inclusion criteria with a substantial space-occupying effect) was classified as sICH.

Characteristics at baseline for patients with HI, PH, and sICH were compared with patients without sICH. We assessed the relation of clinical and radiological characteristics with the occurrence of HI and PH using multinomial logistic regression analysis and sICH using binary logistic regression analysis. Univariable tests were used to identify variables associated with HI, PH, and sICH. Variables with an association with P<0.10 were included in the multivariable regression analysis. The following variables collected at baseline were explored for their association with HI, PH, and sICH: Alberta Stroke Program Early CT Score (ASPECTS), admission collateral score, EVT, administration of intravenous thrombolytics, age, sex, systolic blood pressure (measured on admission), NIHSS, known hypercholesterolemia and statin use, antiplatelet use, atrial fibrillation, time from onset to randomization, diabetes mellitus, and previous stroke.

Criteria for diagnosing diabetes mellitus in the Netherlands are diabetes symptoms (polyuria and polydipsia) and a venous plasma glucose concentration ≥11.1 mmol/L or a fasting plasma glucose concentration ≥7.0 mmol/L.

Hypercholesterolemia is defined as a total cholesterol of ≥6.5 mmol/L.

An additional analysis was conducted to explore possible differences in associations with HI, PH, and sICH between patients treated with EVT or not treated with EVT. Therefore, the groups HI, PH, and sICH were all divided per treatment, patients treated with EVT, and control group, respectively. The control group consisted of all patients that did not receive EVT. Revascularization rate assessed with modified Treatment in Cerebral Ischemia (mTICI) scores was available for patients treated with EVT; therefore, we added this variable to the analysis of patients with sICH after EVT.

As discriminating HT from contrast staining may be difficult on a 24-hour CT scan, HI rates on scans acquired at 24 hours or 5 to 7 days were compared.

Baseline characteristics were analyzed with the Mann-Whitney U test for nonnormally distributed continuous data, Student t test for normally distributed continuous data, and the χ² test for categorical data. The statistical analyses were performed using R (R Core Team [version 3.5.1 (2016)]; R: A language and environment for statistical computing; R Foundation for Statistical Computing, Vienna, Austria. Used packages: MASS, rms, Tableone).

Results

Of the 500 patients included in the MR CLEAN trial, 478 patients were included in this study. In 22 patients, follow-up imaging was missing. Of these 478 patients, 361 CT scans were performed at ≤5 days (3–9 days) and 117 CT scans at 24 hours after inclusion.

Of all 478 patients, 46% had an HT (n=222). Of the patients with HT, 66% had HI (n=147), and 34% had PH (n=75). sICH was observed in 35 patients (7.3%). In the sICH group, 2 patients had a subarachnoid hemorrhage. Both patients with a subarachnoid hemorrhage had undergone EVT. HI was found in 36 of 117 (31%) patients on 24-hour imaging and in 111 of 361 (31%) patients on 5-day follow-up imaging.

Characteristics at baseline for patients with HI, PH, and sICH compared with patients without HT are presented in Table 1. Occurrence of any HT or sICH was evenly distributed among all 4 possible treatments: EVT+intravenous alteplase, intravenous alteplase, EVT only, and patients without treatment. Compared with patients without any HT, patients with HI had a higher median NIHSS score (19 versus 17, P<0.01) and lower median ASPECTS score (9 [7–10] versus 9 [8–10], P<0.01). In the multivariable regression analysis presented in Table 2, HI was significantly associated with baseline NIHSS score (odds ratio [OR], 1.05; 95% CI, 1.01–1.09 [per point]) and with absent/poor collaterals (OR, 1.88; 95% CI, 1.04–3.39).

Statistical Analysis

For the statistical analysis, 2 analyses were performed: (1) patients with HI (HI1 and HI2) and patients with PH (PH1 and PH2) were both compared with patients without HT; (2) patients with any sICH were compared with patients without sICH. We assessed the relation of clinical and radiological characteristics with the occurrence of HI and PH using multinomial logistic regression analysis and sICH using binary logistic regression analysis. Univariable tests were used to identify variables associated with HI, PH, and sICH. Variables with an association with P<0.10 were included in the multivariable regression analysis. The following variables collected at baseline were explored for their association with HI, PH, and sICH: Alberta Stroke Program Early CT Score (ASPECTS), admission collateral score, EVT, administration of intravenous thrombolytics, age, sex, systolic blood pressure (measured on admission), NIHSS, known hypercholesterolemia and statin use, antiplatelet use, atrial fibrillation, time from onset to randomization, diabetes mellitus, and previous stroke.

Criteria for diagnosing diabetes mellitus in the Netherlands are diabetes symptoms (polyuria and polydipsia) and a venous plasma glucose concentration ≥11.1 mmol/L or a fasting plasma glucose concentration ≥7.0 mmol/L.

Hypercholesterolemia is defined as a total cholesterol of ≥6.5 mmol/L.

An additional analysis was conducted to explore possible differences in associations with HI, PH, and sICH between patients treated with EVT or not treated with EVT. Therefore, the groups HI, PH, and sICH were all divided per treatment, patients treated with EVT, and control group, respectively. The control group consisted of all patients that did not receive EVT. Revascularization rate assessed with modified Treatment in Cerebral Ischemia (mTICI) scores was available for patients treated with EVT; therefore, we added this variable to the analysis of patients with sICH after EVT.
Patients with PH had a higher NIHSS score (19 versus 17, P<0.01), were more commonly known with atrial fibrillation (39% versus 23%, P<0.01), had a higher systolic blood pressure (155 versus 142, P<0.01), and used more often antiplatelet agents (44% versus 26%, P<0.01) than patients without HT. In addition, more patients with PH had a history of hypercholesterolemia and statin use (32% versus 20%, P=0.03). In the multivariable regression analysis presented in Table 2, PH was only significantly associated with atrial fibrillation (OR, 1.93; 95% CI, 1.07–3.45) and systolic blood pressure (OR, 1.17; 95% CI, 1.05–1.31 [per 10 mm Hg]).

Of the 35 patients diagnosed with sICH, 30 patients had PH, 3 patients had HI, and 2 patients had subarachnoid hemorrhage. Patients with sICH were older (75 versus 65 years, P<0.001), had a higher NIHSS score (19 versus 17, P<0.01), had more often diabetes mellitus (31% versus 11%, P<0.01), and had a higher systolic blood pressure (158 versus 140, P<0.01) than patients without sICH. Pretreatment antiplatelet use was more common among patients with sICH (60% versus 26%, P<0.01) as was hypercholesterolemia and statin use (49% versus 20%, P<0.01). In the multivariable regression analysis presented in Table 3, sICH was significantly associated with systolic blood pressure (OR, 1.28; 95% CI, 1.11–1.47 [per 10 mm Hg]) and antiplatelet use (OR, 2.6; 95% CI, 1.08–6.3).

### Differences Per Treatment
Clinical and imaging characteristics at baseline of patients with HI and PH differed per treatment group and are presented in Table I in the online-only Data Supplement. In the control group, that consisted of all patients that did not receive EVT, patients with HI had a significantly higher baseline NIHSS score (19 versus 17, P<0.01) than patients with PH (159 versus 143, P<0.01). In the EVT group, the association with systolic blood pressure and PH was not apparent. The univariable analyses of HI and PH per treatment group are presented in Table II in the online-only 2039

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**Table 1. Clinical and Radiological Characteristics at Baseline**

<table>
<thead>
<tr>
<th></th>
<th>No HT (n=256)</th>
<th>HI (n=147)</th>
<th>P Value</th>
<th>PH (n=75)</th>
<th>P Value</th>
<th>No (n=443)</th>
<th>Yes (n=35)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EVT+IV alteplase</td>
<td>105 (41)</td>
<td>58 (40)</td>
<td>0.9</td>
<td>35 (47)</td>
<td>0.78</td>
<td>182 (41)</td>
<td>16 (46)</td>
<td>0.91</td>
</tr>
<tr>
<td>IV alteplase only</td>
<td>123 (48)</td>
<td>73 (50)</td>
<td></td>
<td>34 (45)</td>
<td></td>
<td>215 (49)</td>
<td>15 (43)</td>
<td></td>
</tr>
<tr>
<td>EVT only</td>
<td>17 (6.6)</td>
<td>8 (5.4)</td>
<td></td>
<td>4 (5.3)</td>
<td></td>
<td>27 (6.1)</td>
<td>2 (5.7)</td>
<td></td>
</tr>
<tr>
<td>No treatment</td>
<td>11 (4.3)</td>
<td>8 (5.4)</td>
<td></td>
<td>2 (2.7)</td>
<td></td>
<td>19 (4.3)</td>
<td>2 (5.7)</td>
<td></td>
</tr>
<tr>
<td>Age, y, median [IQR]</td>
<td>64 [53–75]</td>
<td>66 [57–76]</td>
<td>0.16</td>
<td>66 [59–78]</td>
<td>0.19</td>
<td>65 [54–75]</td>
<td>75 [62–80]</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>History of ischemic stroke, n (%)</td>
<td>26 (10)</td>
<td>15 (10)</td>
<td>0.99</td>
<td>10 (13)</td>
<td>0.44</td>
<td>44 (9.9)</td>
<td>7 (20)</td>
<td>0.06</td>
</tr>
<tr>
<td>Atrial fibrillation, n (%)</td>
<td>58 (23)</td>
<td>42 (29)</td>
<td>0.19</td>
<td>29 (39)</td>
<td>&lt;0.01</td>
<td>118 (27)</td>
<td>11 (31)</td>
<td>0.54</td>
</tr>
<tr>
<td>Diabetes mellitus, n (%)</td>
<td>27 (11)</td>
<td>22 (15)</td>
<td>0.191</td>
<td>12 (16)</td>
<td>0.2</td>
<td>50 (11)</td>
<td>11 (31)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Systolic blood pressure, median [IQR]</td>
<td>142 [130–160]</td>
<td>140 [125–155]</td>
<td>0.83</td>
<td>155 [137–169]</td>
<td>&lt;0.01</td>
<td>140 [127–160]</td>
<td>158 [143–168]</td>
<td>0.01</td>
</tr>
<tr>
<td>Collateral score, n (%)†</td>
<td>&lt;0.01</td>
<td>0.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent/poor collaterals</td>
<td>70 (28)</td>
<td>56 (39)</td>
<td>0.52</td>
<td>48 (64)</td>
<td>0.51</td>
<td>262 (59)</td>
<td>22 (63)</td>
<td>0.67</td>
</tr>
<tr>
<td>Moderate collaterals</td>
<td>100 (39)</td>
<td>61 (42)</td>
<td>28 (38)</td>
<td>177 (40)</td>
<td>12 (36)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good collaterals</td>
<td>84 (33)</td>
<td>28 (19)</td>
<td>15 (21)</td>
<td>122 (28)</td>
<td>5 (15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex (male), n (%)</td>
<td>153 (60)</td>
<td>83 (57)</td>
<td>0.52</td>
<td>48 (64)</td>
<td>0.51</td>
<td>262 (59)</td>
<td>22 (63)</td>
<td>0.67</td>
</tr>
<tr>
<td>Antiplatelet use, n (%)</td>
<td>66 (26)</td>
<td>37 (25)</td>
<td>0.892</td>
<td>33 (44)</td>
<td>&lt;0.01</td>
<td>115 (26)</td>
<td>21 (60)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Hypercholesterolemia and statin use, n (%)</td>
<td>50 (20)</td>
<td>33 (22)</td>
<td>0.49</td>
<td>24 (32)</td>
<td>0.03</td>
<td>90 (20)</td>
<td>17 (49)</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

ASPECTS denotes early ischemic changes and NIHSS denotes stroke severity. ASPECTS indicates Alberta Stroke Program Early CT Score; CTA, CT-angiography; EVT, endovascular therapy; HI, hemorrhagic infarction; HT, hemorrhagic transformation; ICH, intracranial hemorrhage; IQR, interquartile range; IV, intravenous; NIHSS, National Institutes of Health Stroke Scale; and PH, parenchymal hematoma.

*ASPECTS was missing for 4 patients.
†Collateral score was assessed on baseline CTA as absent/poor collaterals (0% and >50% filling of occluded are), moderate collaterals (filling of 50% and <100% of occluded area) and good collaterals (100% filling). Collateral score was not available for 6 patients.
Characteristics at baseline for patients with sICH per treatment group are presented in Table III in the online-only Data Supplement. Most associations in the sICH group did not differ per treatment group. However, in the EVT group, patients with sICH had more often diabetes mellitus (53% versus 10%, \(P<0.01\)) than patients without sICH. The number of patients with diabetes mellitus was evenly distributed between sICH or no sICH in the control group. Diabetes mellitus was significantly associated with sICH in the EVT group (OR, 4.3; 95% CI, 1.09–16.8), but not in the control group, and systolic blood pressure was significantly associated with sICH in the control group (OR, 1.25; 95% CI, 1.02–1.53), but not in the EVT group (Table IV in the online-only Data Supplement). Revascularization rate (mTICI scores) was not significantly associated with sICH in the EVT group.

**Discussion**

In our study, baseline characteristics that were associated with HT differ between HT subtypes. HI was significantly associated with an absent/poor collateral score and increased NIHSS score, whereas PH and sICH were significantly associated with increased systolic blood pressure, atrial fibrillation, and antiplatelet use.

Recent studies exploring associations with HT after EVT reported various results.\(^7\)\(-9,21,22\) Altogether, possible risk factors for HT after treatment with EVT that have been reported are an increased NIHSS score, hyperglycemia, antiplatelet use, atrial fibrillation, decreased ASPECTS, increased time from stroke onset to recanalization, diabetes mellitus, and age.\(^7\)\(-9,21,22\) Although it used to be considered as a major risk for HT, treatment with IVT has not been reported as a risk factor for HT or sICH.\(^8,21,25\)

When considering all effect estimates, including nonsignificant associations, our study seems to confirm presumed different underlying mechanisms for different hemorrhage types.\(^26\) Hemorrhage development per se (HI and PH) is more likely in patients with risk factors for large infarcts (ie, worse collateral scores and higher NIHSS score). The paradoxical effect estimate for ASPECTS can probably be explained by inclusion of both ASPECTS and collateral score in the same model, 2 variables very much related.\(^27\) Larger hemorrhages that are more likely to be symptomatic (PH and sICH) might more likely develop if an additional risk factor is present: an increased hydrostatic pressure (blood pressure), impaired
hemostasis (antiplatelet medication), or a combination (patients with atrial fibrillation).7,28 With this potential mechanism in mind, elevated systolic blood pressures after revascularization might be especially harmful. A previous study suggests an association of high systolic blood pressure after revascularization with unfavorable functional outcome.29 However, in the analysis of sICH per treatment, mTICI scores were not significantly associated with sICH, which is probably because a loss of power as only 15 patients with sICH had mTICI scores.

While exploring associations with HT in the EVT and control group, all variables differed between treatment group in their association with HT. Systolic blood pressure was significantly associated with sICH in the control group, and diabetes mellitus was significantly associated with sICH after treatment with EVT. However, previous studies did not indicate an interaction between increased serum glucose and EVT on sICH as outcome measure.30,31 Differences in associations with HT between treatment with EVT and the control group might indicate that risk factors for HT are not necessarily the same after EVT and IVT. However, the associations between EVT and control group only slightly differed, and most patients that had EVT also had treatment with IVT. Therefore, differences in risk factors between patients treated with EVT only and IVT should be assessed and then, exclusion criteria for EVT may be reexamined. It is possible that more patients could be included for EVT.

In agreement with previous studies,8,21,25 neither IVT or EVT were significantly associated with HT in our study. As pre-treatment with IVT is standard of care in eligible patients,32 all patients without IVT had contraindications for IVT. Therefore, no reliable estimate of the true effect of tPA (tissue-type plasminogen activator) on hemorrhage rates can be made. Ongoing trials that randomize between IVT followed by EVT and EVT alone (MR CLEAN-NO IV [Multicenter Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands], SWIFT DIRECT [Solitaire With the Intention for Thrombectomy Plus Intravenous t-PA Versus DIRECT Stent-Retriever Thrombectomy in Acute Anterior Circulation Stroke], DIRECT-SAFE [A Randomized Controlled Trial of DIRECT Endovascular Clot Retrieval Versus Standard Bridging Thrombolysis With Endovascular Clot Retrieval Within 4.5 Hours of Stroke Onset], and DIRECT MT [Parallel Group, Randomized Clinical Trial of Direct Intra-arterial Thrombectomy Versus Intravenous Thrombolysis With Intra-arterial Thrombectomy for Patients With Large Vessel Occlusion of the Anterior Circulation]) will give us valuable information about the actual impact of IVT on HT.33–36

Our study had several limitations. First, our purpose of this study was to identify variables associated with HT, and therefore, we did not adjust for potential confounders. Consequently, the associated variables in this study should not be interpreted as causal factors for HT. Second, not all follow-up CT scans at 5 days could be retrieved due to death.

### Table 3. Univariable and Multivariable Associations With sICH (Binary Logistic Regression)

<table>
<thead>
<tr>
<th></th>
<th>Univariable</th>
<th>Multivariable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR and 95% CI</td>
<td>P Value</td>
</tr>
<tr>
<td>EVT</td>
<td>1.2 (0.6–2.4)</td>
<td>0.6</td>
</tr>
<tr>
<td>Control group*</td>
<td>0.9 (0.34–3.12)</td>
<td>0.85</td>
</tr>
<tr>
<td>Age</td>
<td>1.05 (1.02–1.08)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Baseline NIHSS</td>
<td>1.05 (0.99–1.12)</td>
<td>0.11</td>
</tr>
<tr>
<td>History of ischemic stroke</td>
<td>2.27 (0.87–5.24)</td>
<td>0.07</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>1.26 (0.58–2.6)</td>
<td>0.54</td>
</tr>
<tr>
<td>Diabetes Mellitus</td>
<td>3.6 (1.61–7.65)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Systolic blood pressure per 10 mmHg</td>
<td>1.32 (1.17–1.5)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Time from stroke onset to randomization per 10 min</td>
<td>1.03 (0.98–1.08)</td>
<td>0.2</td>
</tr>
<tr>
<td>ASPECTS</td>
<td>0.95 (0.81–1.13)</td>
<td>0.52</td>
</tr>
<tr>
<td>Collateral score†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate collaterals</td>
<td>1.65 (0.6–5.31)</td>
<td>0.36</td>
</tr>
<tr>
<td>Absent/Poor collaterals</td>
<td>2.79 (1.06–8.73)</td>
<td>0.05</td>
</tr>
<tr>
<td>Sex</td>
<td>1.17 (0.58–2.44)</td>
<td>0.67</td>
</tr>
<tr>
<td>Antiplatelet use</td>
<td>4.28 (2.12–8.87)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Hypercholesterolemia and statin use</td>
<td>3.7 (1.82–7.5)</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

All variables with an association with P<0.1 were included in the multivariable regression analysis. ASPECTS denotes early ischemic changes, and NIHSS denotes stroke severity. ASPECTS indicates Alberta Stroke Program Early CT Score; EVT endovascular therapy; NIHSS, National Institutes of Health Stroke Scale; OR, odds ratio; and sICH, symptomatic intracranial hemorrhage.

*Control group consists of all patients that did not receive EVT.
†Collateral score with good collaterals as reference level.
of variables that were included in the analysis.38 Should be interpreted carefully. Last, although we selected HT than diastolic blood pressure or known hypertension. Furthermore, this was a post hoc study, and therefore, results in previous studies, as well as in this analysis, baseline systolic blood pressure measured on admission, which only represents a snap-shot in time. Multiple measurements of blood pressure were not available. However, in previous studies, as well as in this analysis, baseline systolic blood pressure had a stronger relation with outcome and HT than diastolic blood pressure or known hypertension.37 Furthermore, this was a post hoc study, and therefore, results should be interpreted carefully. Last, although we selected variables with care, it should be considered that some associations might have occurred by chance due to the large number of variables that were included in the analysis.38

In conclusion, scores indicating severe strokes, such as poor collaterals and high NIHSS score, are associated with HI, whereas additional clinical characteristics, such as high systolic blood pressure, atrial fibrillation, and antplatelet use, are associated with PH or sICH. This information could be used to target patients with high-risk characteristics for HT to offer more intense monitoring and even blood pressure control as it might reduce HT risk.39

Appendix

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