Brief Reports

Relationship Between Baseline Blood Pressure Parameters (Including Mean Pressure, Pulse Pressure, and Variability) and Early Outcome After Stroke

Data From the Tinzaparin in Acute Ischaemic Stroke Trial (TAIST)

Chamila Geeganage, PhD; Michael Tracy, MSc; Timothy England, MRCP; Gillian Sare, MRCP; Thierry Moulin, MD; France Woimant, MD; Hanne Christensen, PhD; Peter Paul De Deyn, MD; Didier Leys, MD; Desmond O’Neill, FRCP; E. Bernd Ringelstein, MD; Philip M.W. Bath, FRCP; for TAIST Investigators

Background and Purpose—High blood pressure (BP) in acute stroke is associated independently with a poor outcome. Recent evidence suggests that other hemodynamic parameters including pulse pressure (PP), mean arterial pressure (MAP), heart rate, rate pressure product, and BP variability may also be associated with outcomes following stroke. This study explores the possible relationship between BP and other important hemodynamic parameters, with early outcomes using data from TAIST trial.

Methods—The relationship between baseline BP, heart rate, and other hemodynamic parameters, and early outcomes were assessed using binary logistic regression with adjustment for baseline prognostic factors, time to treatment and treatment assignment. Significance was set at \( P < 0.05 \), and OR and 95% CI were obtained. All analysis was performed using SPSS 16 for Mac (SPSS, Inc.).

Results

Study Participants

The TAIST trial compared high-dose tinzaparin, medium-dose tinzaparin, and aspirin <48 hours after acute ischemic stroke. Four clinical outcome measures were assessed: death, neurologic deterioration from the initial stroke, death or deterioration, and stroke recurrence. Three outcomes on the day-10 computed tomography scan were also assessed: cerebral edema, cerebral bleeding (hemorrhagic transformation, intrainfarct hematoma, additional hematoma, or intraventricular bleeding), and clinico-radiological bleeding (clinical deterioration and cerebral bleeding).

Statistical Methods

The relationships between hemodynamic parameters and early outcomes were studied using binary logistic regression with adjustment for baseline prognostic factors, time to treatment and treatment assignment. Significance was set at \( P < 0.05 \), and OR and 95% CI were obtained. All analysis was performed using SPSS 16 for Mac (SPSS, Inc.).

Results

Study Participants

Analyses included 1479 patients with acute ischemic stroke. Baseline characteristics were as follows: mean age, 71 years; mean systolic BP, 150 mm Hg; mean diastolic BP, 85 mm Hg; mean heart rate, 95 beats per minute; mean MAP, 100 mm Hg; mean PP index, 0.35; and mean BP variability, 0.02.

Early Outcomes at Day 10

Four clinical outcome measures were assessed: death, neurologic deterioration from the initial stroke, death or deterioration, and stroke recurrence. Three outcomes on the day-10 computed tomography scan were also assessed: cerebral edema, cerebral bleeding (hemorrhagic transformation, intrainfarct hematoma, additional hematoma, or intraventricular bleeding), and clinico-radiological bleeding (clinical deterioration and cerebral bleeding).

Key Words: acute stroke ■ blood pressure ■ hemodynamics ■ outcome

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54% males; mean systolic BP, 156.4 mm Hg; and diastolic BP 84.6 mm Hg. At day 10, 60 patients had died; 139 suffered neurologic deterioration; 173 died or deteriorated; 26 died after neurologic deterioration; 53 had a recurrent stroke (ischemic or unknown); 215 had cerebral edema; 448 had cerebral bleeding; and 56 had clinico-radiological bleeding.

Early Outcomes and Baseline Hemodynamics
Death or neurologic deterioration at day 10 was associated with increased systolic BP, MAP, PP, and systolic BP variability in univariate and multivariate analyses (Table, Figure). Similar relationships were observed for neurologic deterioration alone and recurrent stroke (Table). Computed tomography–based early outcome at day 10 was not associated with baseline BP parameters on multiple variable analyses. However, data from International Stroke Trial reported a possible relationship between BP and fatal cerebral edema.1 In the International Stroke Trial analysis, fatal cerebral edema was an outcome derived from other data and did not depend on clinical or imaging data.

Several caveats must be made about this study. Most importantly, the data come from a randomized controlled trial with specific inclusion and exclusion criteria leading to

Discussion
The results of this study found significant positive associations between death or neurologic deterioration, neurologic deterioration alone, and recurrent stroke at day 10 with baseline systolic BP, MAP, and PP, and systolic BP variability. Similar relationships were observed for neurologic deterioration alone and recurrent stroke at day 10. Analysis of computed tomography–based early outcome showed no significant relationship with baseline BP parameters on multiple variable analyses. However, data from International Stroke Trial reported a possible relationship between BP and fatal cerebral edema.1 In the International Stroke Trial analysis, fatal cerebral edema was an outcome derived from other data and did not depend on clinical or imaging data.

Several caveats must be made about this study. Most importantly, the data come from a randomized controlled trial with specific inclusion and exclusion criteria leading to

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Systolic Blood Pressure</th>
<th>Systolic Blood Pressure Variability</th>
<th>Diastolic Blood Pressure</th>
<th>Heart Rate</th>
<th>Mean Arterial Pressure</th>
<th>Pulse Pressure</th>
<th>Pulse Pressure Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death (unadjusted)</td>
<td>1.001 (0.989–1.012)</td>
<td>1.012 (0.988–1.038)</td>
<td>1.013 (0.992–1.035)</td>
<td>1.054* (1.015–1.093)</td>
<td>1.007 (0.989–1.026)</td>
<td>0.985 (0.981–1.009)</td>
<td>0.311 (0.051–1.896)</td>
</tr>
<tr>
<td>Death (adjusted)</td>
<td>1.010 (0.995–1.025)</td>
<td>1.013 (0.986–1.041)</td>
<td>1.027 (0.999–1.055)</td>
<td>1.017 (0.993–1.043)</td>
<td>1.022 (0.998–1.047)</td>
<td>1.003 (0.986–1.021)</td>
<td>0.455 (0.047–4.393)</td>
</tr>
<tr>
<td>Deterioration (unadjusted)</td>
<td>1.011 (1.003–1.019)</td>
<td>1.025 (1.009–1.042)</td>
<td>1.007 (0.992–1.021)</td>
<td>1.013 (0.999–1.028)</td>
<td>1.013* (1.000–1.026)</td>
<td>1.014* (1.005–1.023)</td>
<td>3.309* (1.022–10.712)</td>
</tr>
<tr>
<td>Deterioration (adjusted)</td>
<td>1.019 (1.008–1.030)</td>
<td>1.031 (1.009–1.053)</td>
<td>1.010 (0.990–1.030)</td>
<td>1.014 (0.995–1.033)</td>
<td>1.021* (1.003–1.039)</td>
<td>1.023* (1.010–1.035)</td>
<td>6.671* (1.377–32.311)</td>
</tr>
<tr>
<td>Death/deterioration (unadjusted)</td>
<td>1.009* (1.002–1.016)</td>
<td>1.025* (1.009–1.041)</td>
<td>1.010 (0.997–1.023)</td>
<td>1.017* (1.004–1.030)</td>
<td>1.013* (1.001–1.024)</td>
<td>1.010* (1.002–1.018)</td>
<td>1.904 (0.651–5.567)</td>
</tr>
<tr>
<td>Death/deterioration (adjusted)</td>
<td>1.017* (1.007–1.027)</td>
<td>1.030* (1.010–1.052)</td>
<td>1.014 (0.997–1.032)</td>
<td>1.010 (0.993–1.027)</td>
<td>1.022* (1.006–1.038)</td>
<td>1.019* (1.008–1.030)</td>
<td>3.503 (0.852–14.405)</td>
</tr>
<tr>
<td>Recurrence (unadjusted)</td>
<td>1.020* (1.008–1.033)</td>
<td>1.025* (1.001–1.045)</td>
<td>1.016 (0.993–1.039)</td>
<td>1.006 (0.985–1.029)</td>
<td>1.026* (1.006–1.046)</td>
<td>1.021* (1.007–1.034)</td>
<td>6.147* (1.023–36.946)</td>
</tr>
<tr>
<td>Recurrence (adjusted)</td>
<td>1.031* (1.013–1.049)</td>
<td>1.024 (0.997–1.052)</td>
<td>1.025 (0.995–1.057)</td>
<td>1.015 (0.986–1.046)</td>
<td>1.040* (1.012–1.069)</td>
<td>1.028* (1.008–1.044)</td>
<td>7.586 (0.719–80.034)</td>
</tr>
</tbody>
</table>

*Significant result.
selection bias. First, patients with BP >220/120 mm Hg were excluded from TAIST, and hence, no data are available for those with severe hypertension. Second, only patients with baseline modified Rankin Scale ≤2 were included in TAIST trial, and therefore, qualifying stroke events were not severe and disabling. As a result, the strength of relationship between hemodynamic measures and functional outcome may be an underestimate. Third, exclusion of patients with serious comorbid factors, such as myocardial infarction, may have resulted in an under-representation of patients with low BP; this will have affected the ability to identify the “U-shaped” curve relating BP and functional outcome. Fourth, TAIST allowed randomization out to 48 hours from ictus; therefore, some patients with raised BP will have been missed, since BP falls in some individuals during the first 6 hours after stroke.7 Fifth, patients who had hemorrhagic transformation on their baseline scan were excluded, which will have led to a relative under-recruitment of patients with severe stroke. Nevertheless, data in this analysis come from a large, hi-fidelity, double-blind, double-dummy trial where outcomes and computed tomography findings were reviewed by independent adjudicators blinded to treatment allocation.

In summary, this analysis provides new evidence on the relationship between BP parameters with early adverse outcomes in acute ischemic stroke. These measures offer a potential therapeutic target for improving early outcome after acute ischemic stroke.

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Disclosures

P.M.W.B. was chief investigator for the TAIST Trial. T.M., F.W., P.D.D., D.L., D.O., E.B.R., and P.M.W.B. were members of the TAIST Trial Steering Committee.

References

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