Acute Hypertensive Response in Stroke: Pathophysiology and Management

Adnan I. Qureshi MD

Professor, Neurology, Neurosurgery, and Radiology
President, International Society of Interventional Neurology

For the ATACH II Investigators

Zeenat Qureshi Stroke Research Center
University of Minnesota, Minneapolis, MN
Initial Systolic Blood Pressure in Patients Presenting to the Emergency Room with Stroke in US
(National Hospital Ambulatory Medical Care Survey 2003)

Acute Hypertensive Response

• Stroke specific
• Transient
• Prognostic significance

(Qureshi AI: Circulation 2008 Jul 8;118(2):176-87)
Acute hypertensive response: Stroke specific disruption of autonomic activity

Disruption: structural and/or functional

Parasympathetic activity

Sympathetic activity

Adaptation: functional

BP

(Qureshi AI: Circulation 2008 Jul 8;118(2):176-87)
Treatment of acute hypertensive response in ischemic stroke

(Qureshi AI: Circulation 2008 Jul 8;118(2):176-87)
Reduction in cerebral blood flow
SPECT scan
Severe hypoperfusion (core) - mild to moderate hypoperfusion (penumbra) alive but at risk
Cerebral blood flow and cell death
Perfusion-Diffusion mismatch

Diffusion-weighted MRI
Perfusion-weighted MRI

Diffusion-weighted MRI: Clear depiction of lesion
Perfusion-weighted MRI: Blood volume, large perfusion deficit
Hypoperfused but alive—potentially salvageable—Penumbra

Diffusion-weighted MRI

Perfusion-weighted MRI
Hypoperfused but alive—vulnerability to systemic BP change—impaired autoregulation—collaterals are BP dependant.

SBP=100 mm Hg

SBP=160 mm Hg
Current guidelines are based on the policy of avoiding further ischemic injury.
Intravenous Nimodipine West European Stroke Trial

Total anterior circulation infarction (n=106)
- Placebo
- IV nimodipine 1 or 2 mg/h
- No difference in outcome

Within 24 hours

Partial anterior circulation infarction (n=62)
- Placebo
- IV nimodipine 1 or 2 mg/h
- Diastolic BP reduction associated with neurological deterioration and outcome

Diastolic BP reduction associated with neurological deterioration and outcome
BP reduction harmful?

BP reduction no effect?

Courtesy of David S. Liebeskind MD, UCLA Stroke Center, LA
Acute hypertensive response should not be treated in ischemic stroke

Qureshi AI: Circulation 2008 Jul 8;118(2):176-87

A subgroup of patients may deteriorate

Benefit of acute blood pressure reduction unclear
Pending more data, emergency administration of antihypertensive agents should be withheld unless the diastolic blood pressure is >120 mm Hg or unless the systolic blood pressure is >220 mm Hg.

The panel remains concerned by the evidence that aggressive lowering of blood pressure among patients may cause neurological worsening, and the goal is to avoid overtreating patients with stroke until definitive data are available.

Treatment of acute hypertensive response in patients receiving thrombolysis

(Qureshi AI: Circulation 2008 Jul 8;118(2):176-87)
Acute hypertensive response may increase the risk of post-thrombolysis intracerebral hemorrhage

(Qureshi AI: Circulation 2008 Jul 8;118(2):176-87)
## SBP and post-thrombolytic ICH

<table>
<thead>
<tr>
<th>Studies</th>
<th>Patients with acute ischemic stroke</th>
<th>Intracranial hemorrhage rate</th>
<th>Predictor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ECASS II</strong> (Stroke. 2001; 32(2):438-41)</td>
<td>793</td>
<td>60 (8%)</td>
<td>Baseline SBP</td>
</tr>
<tr>
<td><strong>Multicenter rt-PA stroke survey</strong> (Circulation 2002;105:1679-1685)</td>
<td>1205</td>
<td>158 (13%)</td>
<td>Pre-treatment SBP</td>
</tr>
<tr>
<td><strong>EPITHET</strong> (Stroke. 2010; 41(1):72-7)</td>
<td>97</td>
<td>15 (15%)</td>
<td>Weighted SBP 1–24 h</td>
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</table>
American Heart Association Guidelines—Thrombolysis

- Systolic blood pressure is $\leq 185$ mm Hg and their diastolic blood pressure is $\leq 110$ mm Hg (Class I, Level of Evidence B) before lytic therapy is started.

- Maintained below 180/105 mm Hg for at least the first 24 hours after intravenous rtPA treatment.

- Blood pressure recommendations should be followed in patients undergoing intra-arterial thrombolysis (Class I, Level of Evidence C).

Acute ischemic stroke and received rt-PA treatment with SBP >180 mm Hg (3-24 hours after symptom onset).

- **Antihypertensive treatment (N=65)**: 32% clinical improvement at 24 hours.
- **No antihypertensive treatment (N=112)**: 52% clinical improvement at 24 hours.
Post-hoc analysis of NINDS rt-PA trial

Acute ischemic stroke and received rt-PA
SBP >180 mm Hg (3-24 hours after symptom onset)

Antihypertensive treatment (N=65)

Clinical improvement at 24 hours
32%

More severe hypertension
More abrupt decline of BP in response to antihypertensive medication

52%
Post-hoc analysis of NINDS rt-PA trial

Acute ischemic stroke and received rt-PA trial 2PA.
24 hours after symptom onset.

More severe hypertension
More abrupt decline of BP in response to antihypertensive medication
(recanalization is associated with spontaneous BP decline)

Antihypertensive treatment (N=65)

Clinical improvement at 24 hours

<table>
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<tr>
<th>Occlusion</th>
<th>Recanalization</th>
<th>Reocclusion</th>
</tr>
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<tbody>
<tr>
<td>BP high</td>
<td>BP normal</td>
<td>BP high</td>
</tr>
</tbody>
</table>
Special considerations-post thrombolytic patients

- Greater level of susceptibility to blood pressure decline/fluctuations (presumably related to recanalization).
- First 6 hours is the period of maximum fluctuations in blood pressure following thrombolytic treatment.
Treatment of acute hypertensive response in intracerebral hemorrhage

Re: Qureshi AI: Lancet 2009;373:1632-44.
Evolution of our understanding of acute hypertensive response

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<td>AGGRESSIVE BP REDUCTION EXPLORED-PILOT STUDIES</td>
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### Evolution of our understanding of acute hypertensive response

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Acute Hypertensive Response Should Not Be Treated

(Powers WJ. Neurology 1993;43:461-467)

Perihematoma ischemia is a serious concern

Hematoma expansion is uncommon
Hibernation stage (0-2 days)  
Reperfusion stage (2-14 days)  
Normalization stage (>14 days)

## Evolution of our understanding of acute hypertensive response

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Hematoma Enlargement

Elevated systolic blood pressure may predispose to hematoma enlargement


- SBP > 200 mm Hg
- No hematoma enlargement
Acute Hypertensive Response Should be Treated

(Qureshi et al.: Lancet 2009;373:1632-44)

Is there perihematoma ischemia?

Hematoma expansion is a reality
Guidelines for the Management of Spontaneous Intracerebral Hemorrhage in Adults. 2007

Guideline From the American Stroke Association Stroke Council

- Until ongoing clinical trials of blood pressure intervention for ICH are completed, physicians must manage blood pressure on the basis of the present incomplete evidence.
- Suspect elevated intracranial pressure—keep systolic blood pressure <180 mm Hg.
- Do not suspect elevated intracranial pressure—keep systolic blood pressure <160 mm Hg. Regular clinical evaluation.

BP reduction and hematoma enlargement

No standard management practices

Single center - AHA guidelines
IV nicardipine 5-15 mg/hr

37%
180 mm Hg
17%
Intracerebral Hemorrhage Specific Intensity of Care Quality Metrics - BP management

An algorithm that evaluates principles of care using the "best available" evidence in a semi-quantitative manner

<table>
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<tr>
<th>Variable</th>
<th>Quality parameter</th>
<th>1 points if YES or not applicable</th>
</tr>
</thead>
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<tr>
<td>Treatment of acute hypertensive response (SBP ≥180 mm Hg)</td>
<td>Time interval between two consecutive SBP≥180 mm Hg AND first SBP&lt;180 mm Hg recording</td>
<td>Achieved target range with 2.5 hours of second of the two consecutive measurements OR not applicable</td>
</tr>
</tbody>
</table>

26 quality indicators related to 18 facets of care

Re: Qureshi AI. Neurocrit Care 2011;14:291-317
Effective and timely reduction of SBP:
Achieved target range with 2.5 hours = 1 point

Figure 3
Baseline
2 hours
24 hours
Intracerebral Hemorrhage Specific Intensity of Care Quality Metrics—VALIDATION STUDY

Score on performance metrics and survival in 50 patients with ICH

Low performance

17

High performance

26

Intracerebral Hemorrhage Specific Intensity of Care
Quality Metrics - 26 quality indicators
Score on performance metrics and survival

Evolution of our understanding of acute hypertensive response

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### Intensive blood pressure reduction in acute cerebral haemorrhage trial (INTERACT) Lancet Neurology 2008;7:391-399

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<th>Variables</th>
<th>Intensive SBP&lt;140mmHg (n=203)</th>
<th>AHA-guideline SBP&lt;180mmHg (n=201)</th>
<th>p-value</th>
</tr>
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<tr>
<td>Hematoma expansion (&gt;33% or 12.5 ml)</td>
<td>15%</td>
<td>23%</td>
<td>0.05</td>
</tr>
</tbody>
</table>


<table>
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<tr>
<th>Variables</th>
<th>SBP reduction ≥60 mmHg (n=32)</th>
<th>SBP reduction &lt;60 mmHg (n=28)</th>
<th>RR (95% CI)</th>
</tr>
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<tbody>
<tr>
<td>Hematoma expansion (&gt;33%)</td>
<td>19%</td>
<td>33%</td>
<td>0.6 (0.2, 1.4)</td>
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*Lancet Neurology 2008;7:391–399*

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<tr>
<td>Hematoma expansion (&gt;33% 12.5 ml)</td>
<td>12%</td>
<td>27%</td>
<td>0.08</td>
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### Antihypertensive Treatment of Acute Cerebral Hemorrhage (ATACH) Study  
*Arch Neurol 2010; 67(5):570–6.*

<table>
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<th>Variables</th>
<th>SBP reduction ≥60 mmHg (n=11)</th>
<th>SBP reduction &lt;60 mmHg (n=9)</th>
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<tr>
<td>Hematoma expansion (&gt;33%)</td>
<td>18%</td>
<td>38%</td>
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### Intensive blood pressure reduction in acute cerebral haemorrhage trial (INTERACT)

#### Variables

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**Attenuation of hematoma expansion with intensive SBP reduction. Attenuation most prominent in patients recruited within 3 h**
Evolution of our understanding of acute hypertensive response

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Primary hypothesis: ATACH II

Intensive SBP reduction\(^1\) reduces the likelihood of death or disability at 3m\(^2\) after ICH by 10% or greater when compared with standard SBP reduction.

1. SBP\(\leq 140\) mmHg using IV nicardipine with treatment initiated within 3.5 h of onset of ICH and continued for the next 24h
2. Defined by mRS score of 4-6
3. SBP\(\leq 180\) mmHg
Trial design: ATACH II

SBP<180 mm Hg

Baseline

SBP<140 mm Hg

24 hrs

3 m
### Overview of the study design-ATACH II

<table>
<thead>
<tr>
<th>Patient screened</th>
<th>ED personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient meets eligibility criteria</td>
<td>Site investigator</td>
</tr>
<tr>
<td>Randomize subjects 1:1</td>
<td>WebDCU™ system at MUSC</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Intensive treatment</th>
<th>Standard treatment</th>
<th>Site investigator</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBP ≤ 140mmHg using IV nicardipine ± labetalol</td>
<td>SBP ≤ 180mmHg using IV nicardipine ± labetalol</td>
<td>Blinded neurological evaluation by site investigator</td>
</tr>
</tbody>
</table>

mRS and Euro-QOL

*FDA-IND-exempt # 107804*
INTERACT II
- Onset < 6 hours
- SBP 150-220 mm Hg

ATACH II
- Onset < 4.5 hours
- SBP > 180 mm Hg
- Hematoma vol. < 60 cc

SCORE IT
- CT spot sign

SBP-66% in 6h
SBP-90% in 2h

Intensity of care
**INTERACT II**
- Onset <6 hours
- SBP 150-220 mm Hg

**ATACH II**
- Onset <4.5 hours
- SBP >180 mm Hg
- Hematoma vol.<60 cc

**SCORE IT**
- CT spot sign

SBP-66% in 6h
SBP-90% in 2h

Intensity of care
Integration: additive OR synergistic?

- ATACH II
- INTERACT II
- SBP reduction < 140 mm Hg
- Time window
- Patient subset
- Time to reach SBP goals

- STICH II
- Surgical evacuation of lobar ICH

- IVH-CLEAR
- Intraventricular hemorrhage + thrombolytics
Treatment of acute hypertensive response: Choosing the right IV antihypertensive agent

The search for the ideal regimen

- Treats underlying pathophysiology
- Rapid onset of action
- Predictable dose response
- Titratable to desired BP
- Minimal dosage adjustments
- Minimal adverse effects
- No increase in ICP
- No coronary or cerebral steal
- Easy transition to oral formulation
Systolic blood pressure recordings for 24 hrs in ICH pts
IV Labetalol+ Hydralazine± Nitroprusside

From: Qureshi AI. Journal of Intensive Care: 2005;20:34-42
Systolic blood pressure recordings for 24 hrs in ICH pts

IV Labetalol + Hydralazine ± Nitroprusside

From: Qureshi AI. Journal of Intensive Care: 2005;20:34-42
Hourly mean arterial pressure recordings for the 24-hour period in ICH pts (IV nicardipine infusion)

From: Qureshi AI. Critical Care Medicine 2006;34:1975-80
Hourly mean arterial pressure recordings for the 24-hour period after initiating IV nicardipine infusion

Infusion based regimens are more effective than bolus based regimens

From: Qureshi AI. Critical Care Medicine 2006;34:1975-80
Antihypertensive medication and intracranial pressure

Intracranial mass lesion + Cerebral blood volume [venous] = ICP

Antihypertensive meds → Cerebral venous dilation → CBV [venous]↑↑
## Comparison of IV antihypertensive agents

<table>
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<tr>
<th>Agent</th>
<th>Mechanism of action</th>
<th>Cerebral blood flow</th>
<th>ICP</th>
<th>Onset of action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labetolol</td>
<td>α &amp; β-adrenergic blockers</td>
<td>...</td>
<td>...</td>
<td>5-10 min</td>
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<tr>
<td>Hydralazine</td>
<td>Direct relaxation of arteriolar smooth muscle</td>
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<td>++</td>
<td>10-20 min</td>
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<td>Nitroprusside</td>
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<td>++</td>
<td>++</td>
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Re: Qureshi AI: Circulation 2008 Jul 8;118(2):176-87
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Re: Qureshi AI: Circulation 2008 Jul 8;118(2):176-87
Summary

## Stroke subtype specific BP treatment recommendations:

**American Stroke Association, Stroke Council**

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<tr>
<th>Stroke Subtype</th>
<th>Management</th>
<th>SBP &lt; 220 mm Hg</th>
<th>SBP &lt; 180 mm Hg</th>
<th>SBP &lt; 160 mm Hg</th>
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<td>Acute ischemic stroke</td>
<td>Not a candidate for thrombolysis</td>
<td></td>
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<tr>
<td></td>
<td>Candidate for thrombolysis</td>
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<td>Acute intracerebral hemorrhage</td>
<td>Suspect high ICP</td>
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<td>Do not suspect high ICP</td>
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<td>Acute subarachnoid hemorrhage</td>
<td>Aneurysm not secured</td>
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<td>Aneurysm secured</td>
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*SBP* indicates systolic blood pressure.
Stroke subtype specific BP treatment recommendations:
American Stroke Association, Stroke Council

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<td>Aneurysm not secured</td>
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<td>SBP &lt; 160 mm Hg</td>
<td>Depends upon presence of vasospasm</td>
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Early diagnosis and differentiation into stroke subtypes is key!!
Conclusions

- Treatment of acute hypertensive response in patients with stroke represents a widely applicable and cost effective intervention to improve patient outcomes.

- However such benefit is contingent on appropriate interpretation, implementation, and integration of results of on-going clinical trials.
Thank you

Zeenat Qureshi Stroke Research Center 2012
INTERACT II
- Onset < 6 hours
- SBP 150-220 mm Hg

ATACH II
- Onset < 4.5 hours
- SBP > 180 mm Hg
- Hematoma vol. < 60 cc

SCORE IT
- CT spot sign

SBP-66% in 6h
SBP-90% in 2h

Intensity of care
### INTERACT II
- Onset <6 hours
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### ATACH II
- Onset <4.5 hours
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### SCORE IT
- CT spot sign

- SBP-90% in 2h
- SBP-66% in 6h

### Intensity of care