Hypoperfusion, Ischemia and Blood Pressure Reduction in Intracerebral Hemorrhage

Didem Aksoy[1,2], Ryan W Snider[1,2], Jonathan Kleinman[1,2], Michael Mlynash[1,2], Nancy Fischbein[3], Roland Bammer[3], Matus Straka[3], Irina Eyngorn[1,2], Alisa Gean[4], Chitra Venkat[1,2], Anna K Finley Caulfield[1,2], and Christine Wijman[1,2]

[1]Department of Neurology and Neurological Sciences, Stanford University, Palo Alto, CA, United States, [2]Stanford Neurocritical Care Program, Stanford Stroke Center, Stanford University Medical Center, Palo Alto, CA, United States, [3]Department of Radiology, Stanford University, Palo Alto, CA, United States, [4]Department of Radiology, University of California, San Francisco, San Francisco, CA, United States

Target Audience: Stroke neurologists, neurologists, neuroradiologists, MR physicists interested in perfusion and diffusion imaging.

Purpose: Optimal blood pressure (BP) management following intracerebral hemorrhage (ICH) remains controversial. Elevated BP has been associated with hematoma expansion. BP reduction may limit hematoma expansion, but may also cause reduced regional perfusion pressures in the perihematomal region, leading to hypoperfusion and ischemia. We examined whether large BP drops are associated with hypoperfusion and ischemia in the perihematomal region.

Methods: Consecutive ICH patients with an MRI within 24 hours of symptom onset were prospectively enrolled. BPs were recorded hourly from hospital presentation to MRI with perfusion (PWI) and diffusion weighted imaging (DWI). MR imaging was performed on a 1.5T GE Signa Excite scanner. Gradient echo (GRE), fluid attenuated inversion recovery (FLAIR), DWI and PWI were acquired and perfusion (T_{max}) maps were generated as previously described in detail [1]. Perihematomal regions of interest (ROI) were generated by subtracting the region of blood products on GRE images from the region defined by T2 hyperintensity on FLAIR. The resulting ROI was transferred to co-registered perfusion maps [2]. Mean time delay for perihematomal blood delivery (T_{max}) was calculated using this ROI. DWI lesions were defined as hyperintense on b=1000 images and hypointense on ADC maps, without evidence of blood on FLAIR or GRE sequences (Figure 1). The magnitude of BP reduction most predictive of decreased perfusion in the perihematomal region was determined.

Results: Thirty-three patients were included (age: 59 (48-75) years; ICH volume: 10.7 (6.6-30.3 mL). Patients with systolic BP (SBP) reductions ≥30% from admission SBP to mean treated SBP had the most delayed bolus arrival on PWI (high Tmax), 7.8s (6.7-8.8) versus 5.6s (4.3-6.9) (p=0.009). Patients with absolute SBP reductions ≥60mmHg also had higher Tmax 7.4s vs 5.6s (p=0.014). Furthermore, patients with admission SBP of 200mmHg and more had higher Tmax, 7.3s vs 5.5s (p=0.018). Eighty-two percent (14/17) of patients with Tmax>6s had DWI lesions versus 31% (5/16) of those with Tmax≤6s (p=0.005). All patients with SBP reduction ≥30% (8/8) had DWI lesions versus 44% (11/25) of those with SBP reduction <30% (p=0.010) (Figure 2).

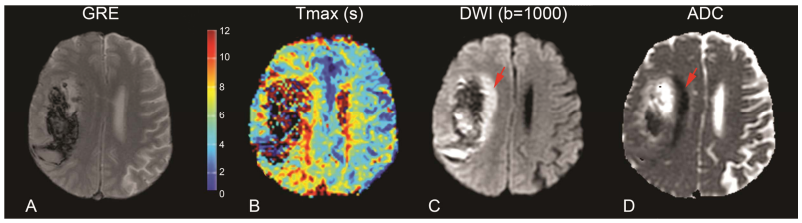

Figure 1. (A) Gradient echo (GRE) MRI showing large lobar hemorrhage, (B) perfusion map (T_{max}) showing perihematomal hypoperfusion outside of the hematoma, (C) diffusion weighted image (DWI) and (D) apparent diffusion coefficient (ADC) map demonstrating a sizable perihematomal lesion medial to the hematoma with reduced diffusion (red arrows).

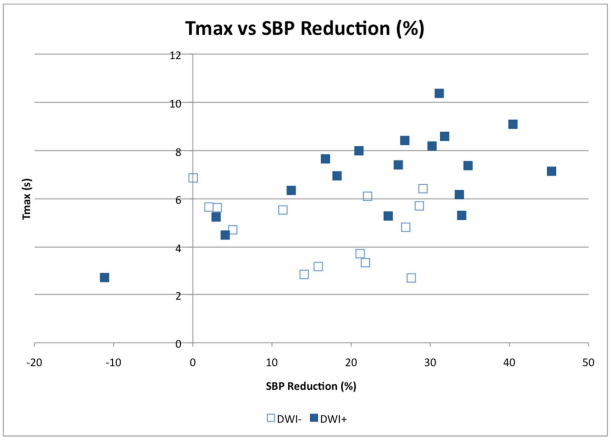

Figure 2. Patients with larger percentages of systolic blood pressure (SBP) lowering from admission to mean SBP had higher T_{max} values and increased frequency of perihematomal diffusion lesions.

Discussion: Aggressive SBP reduction in acute ICH is associated with hypoperfusion and the presence of diffusion lesions in the perihematomal region. Negative effects on regional cerebral perfusion pressure (rCPP) are conceivable, especially in patients with chronic hypertension due to right-shifted cerebral autoregulation curves and, subsequently, a decreased tolerance for low SBPs. Any treatment benefit of BP reduction needs to be weighed against its potential to cause ischemia in the perihematomal region.

Conclusion: Aggressive blood pressure reduction in acute ICH is associated with high T_{max} and the presence of diffusion lesions in the perihematomal region.

References: [1] Straka et al, JMRI, 2010 [2] Olivot et al, Stroke, 2010. **Acknowledgements:** NIH (R01NS03486, R01EB271108, R01EB8706, R01EB6526).