Regional Cerebral Perfusion after Automated Head-Up Cardiopulmonary Resuscitation using MRI

Anja Metzger PhD[1,4], Xiufeng Li PhD[2], Johanna C. Moore MD MSc[3,4], Pouria Pourzand MD[1,4], Christophe Lenglet PhD[2], Hamza Farooq PhD[2], Bayert Salverda BA[4], Mithun Suresh MD[5], Hamza Hai BS, Keith G. Lurie MD[1,4], Gregory J. Metzger PhD[2]

1. University of Minnesota, Minneapolis, MN, United States. 2. University of Minnesota Center for Magnetic Resonance Research, Minneapolis, MN, United States. 3. Hennepin County Medical Center, Minneapolis, MN, United States. 4. Hennepin Healthcare Research Institute, Minneapolis, MN, United States. 5. CentraCare-St. Cloud Hospital, Saint Cloud, MN, United States.

Background

Automated Head Up CPR (AHUP-CPR) combines active compression-decompression CPR with full lift (3-4 cm), an impedance threshold device, and automated controlled head and thorax elevation. Significantly improved cerebral blood flow during CPR and neurological survival has been previously demonstrated in pre-clinical studies.

The impact of AHUP-CPR on regional cerebral perfusion after return of spontaneous circulation (ROSC) has not previously been assessed.

Focus

Measurement of regional cerebral perfusion after ROSC in surviving AHUP vs. conventional (C) CPR swine, as determined by non-contrast, arterial spin-labeled magnetic resonance imaging (ASL-MRI) in a porcine model.

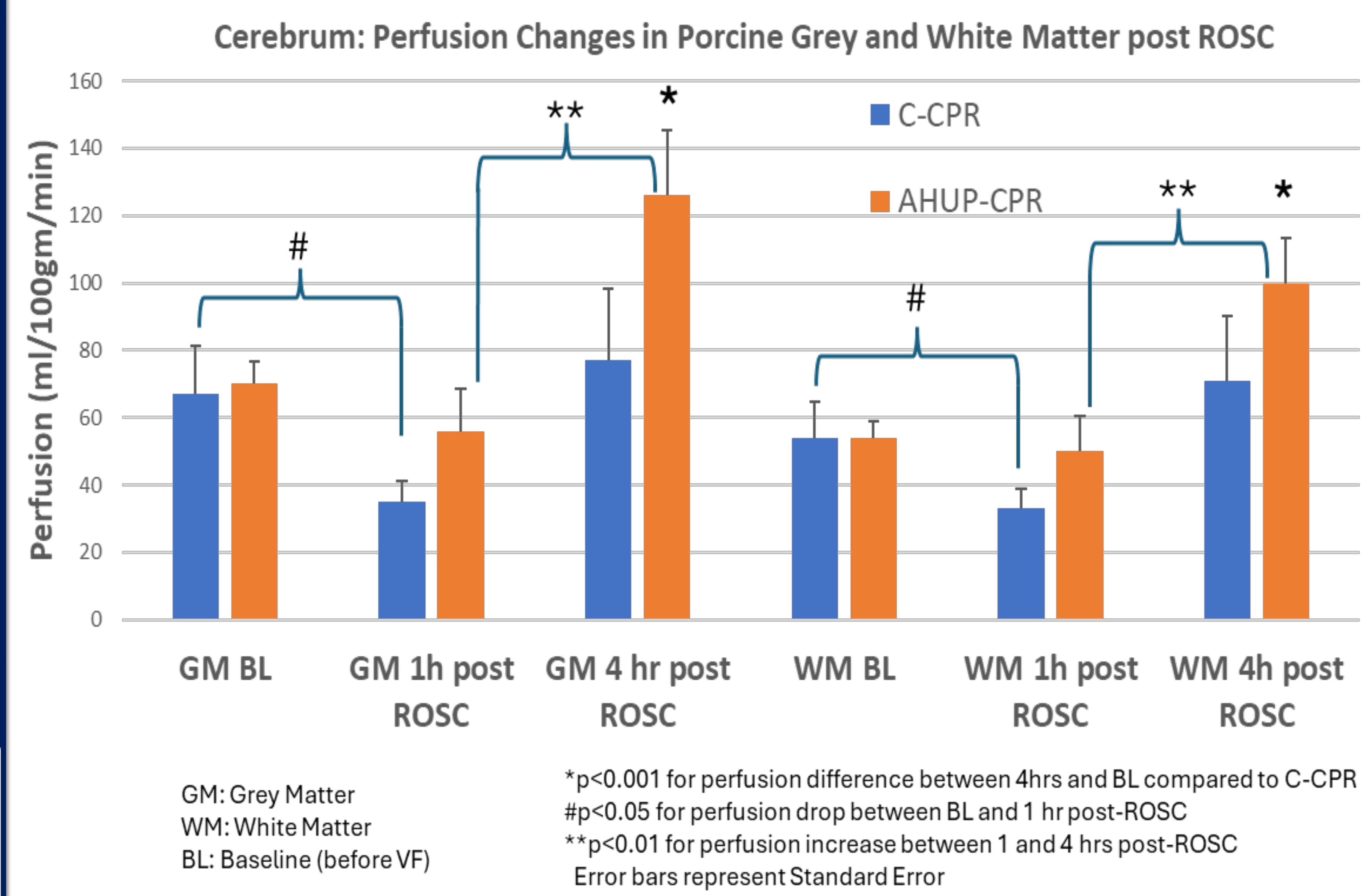

Figure 2. Changes in perfusion in cerebral grey and white matter at Baseline (pre-VF), 1 hr, and 4 hrs post-ROSC in animals treated with AHUP-CPR versus C-CPR.

Results

ROSC was achieved in 7/7 AHUP-CPR pigs and 4/9 C-CPR pigs ($p=0.03$).

One hour post-ROSC cerebral white and grey matter mean perfusion (ml/100gm/min) was significantly lower in the C-CPR pigs ($p<0.05$) (Fig. 2). Four hours post-ROSC, AHUP-CPR pigs had significantly higher cerebral perfusion compared with measurements at 1 hour post-ROSC ($p<0.01$). Significant perfusion differences between C-CPR and AHUP-CPR were also observed in cerebral white and grey matter 4 hours post-ROSC ($p<0.001$). (Fig. 2).

Perfusion changes in the cerebellum were also observed 4 hours post-ROSC (Fig. 3) between groups. Following AHUP-CPR there was increased perfusion in cerebellar white and grey matter compared with C-CPR ($p<0.001$).

Methods

Baseline ASL-MRI scans were performed on 16 (~40kg) anesthetized and intubated swine in the prone position. Ventricular fibrillation was then induced and left untreated for 6 minutes and animals were randomized to AHUP-CPR or automated C-CPR. CPR was performed for 8 minutes before defibrillation and epinephrine was given at 7 minutes and at 3 minutes if diastolic blood pressure was <25 mmHg. If ROSC was obtained, ASL-MRI was performed 1 and 4 hours post-ROSC on a 3 Tesla MRI (Siemens Healthineers, Erlangen, Germany). Pseudo-continuous ASL was performed by placing a 1cm thick labeling slab perpendicular to the pharyngeal artery localized on a maximum intensity projection of a 3D time-of-flight acquisition (Fig. 1). Image readout was performed with a multi-slice echo-planar imaging acquisition in the axial plane angulated to the anterior/posterior commissure. Longitudinal relaxometry mapping was performed with the same slice orientation and readout strategy as the ASL acquisition to facilitate the perfusion data's gray/white matter segmentation.

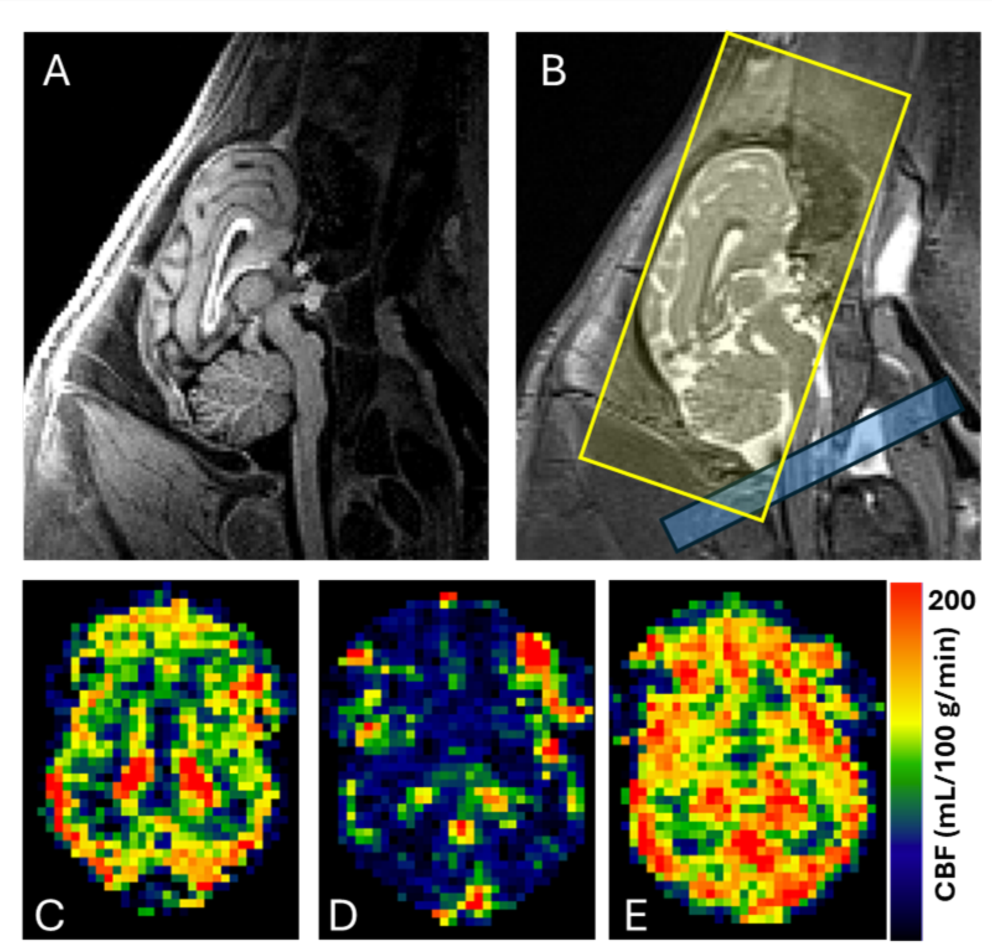

Figure 1. Representative HUP-CPR anatomic and perfusion MRI: Anatomic T1-weighted (A) and T2-weighted (B) anatomic imaging series. Panel (B): the blue box indicates the location where blood is magnetically labeled for the ASL studies and the yellow box indicates the multi-slice imaging volume. The perfusion imaging maps of one mid-brain axial slice are shown at baseline (C), 1h post (D) and 4h post ROSC (E).

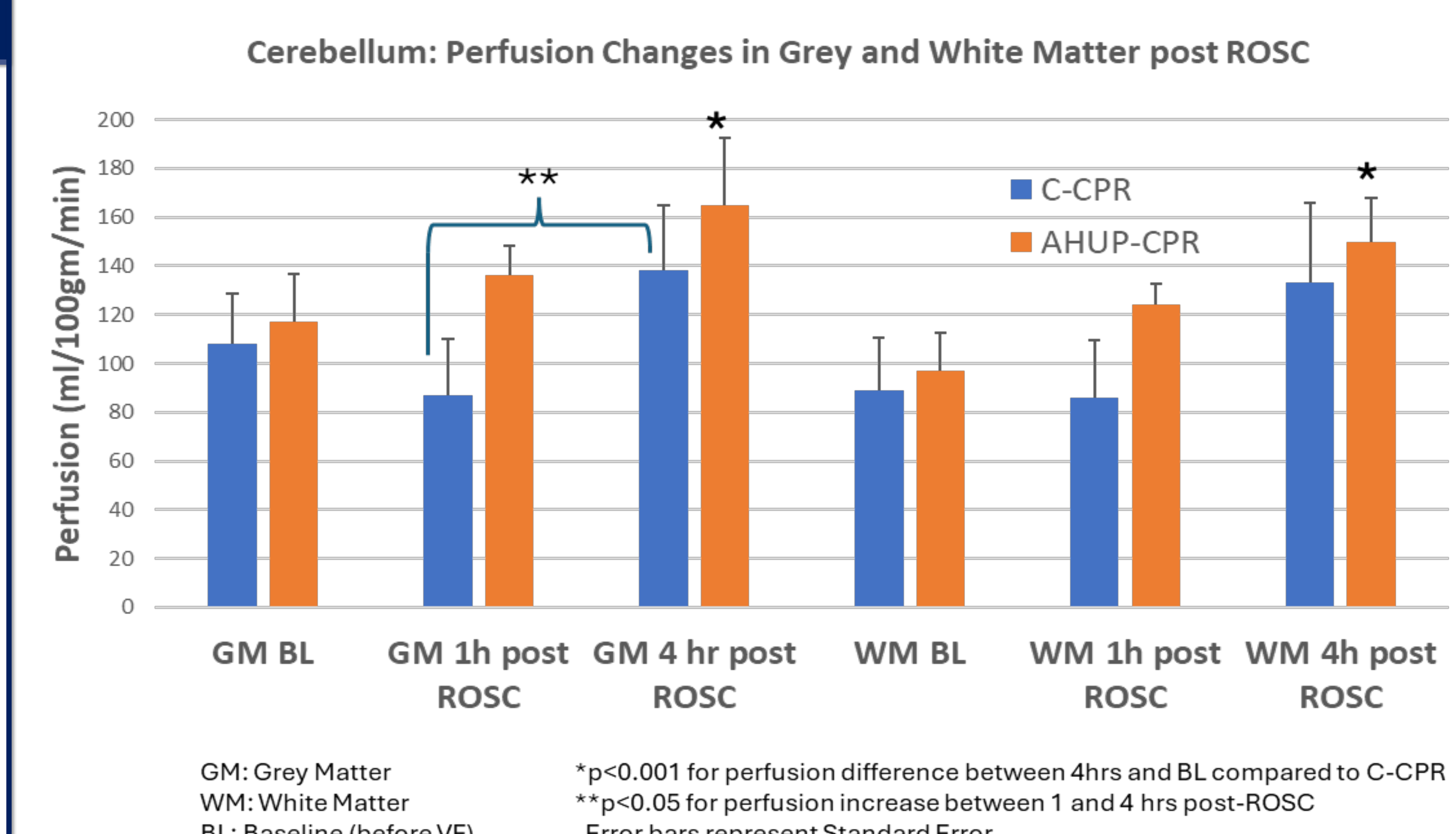

Figure 3. Changes in perfusion in cerebellum grey and white matter.

Conclusions

Animals treated with AHUP-CPR had significantly higher perfusion in the cerebrum and cerebellum after ROSC. Increased regional brain blood flow after ROSC with AHUP-CPR may help explain some of the neurologically sound survival benefit observed with this new approach.