Experimental Laboratory: Piglet Hypoxia-Ischemia

Jennifer K. Lee, MD

Johns Hopkins University

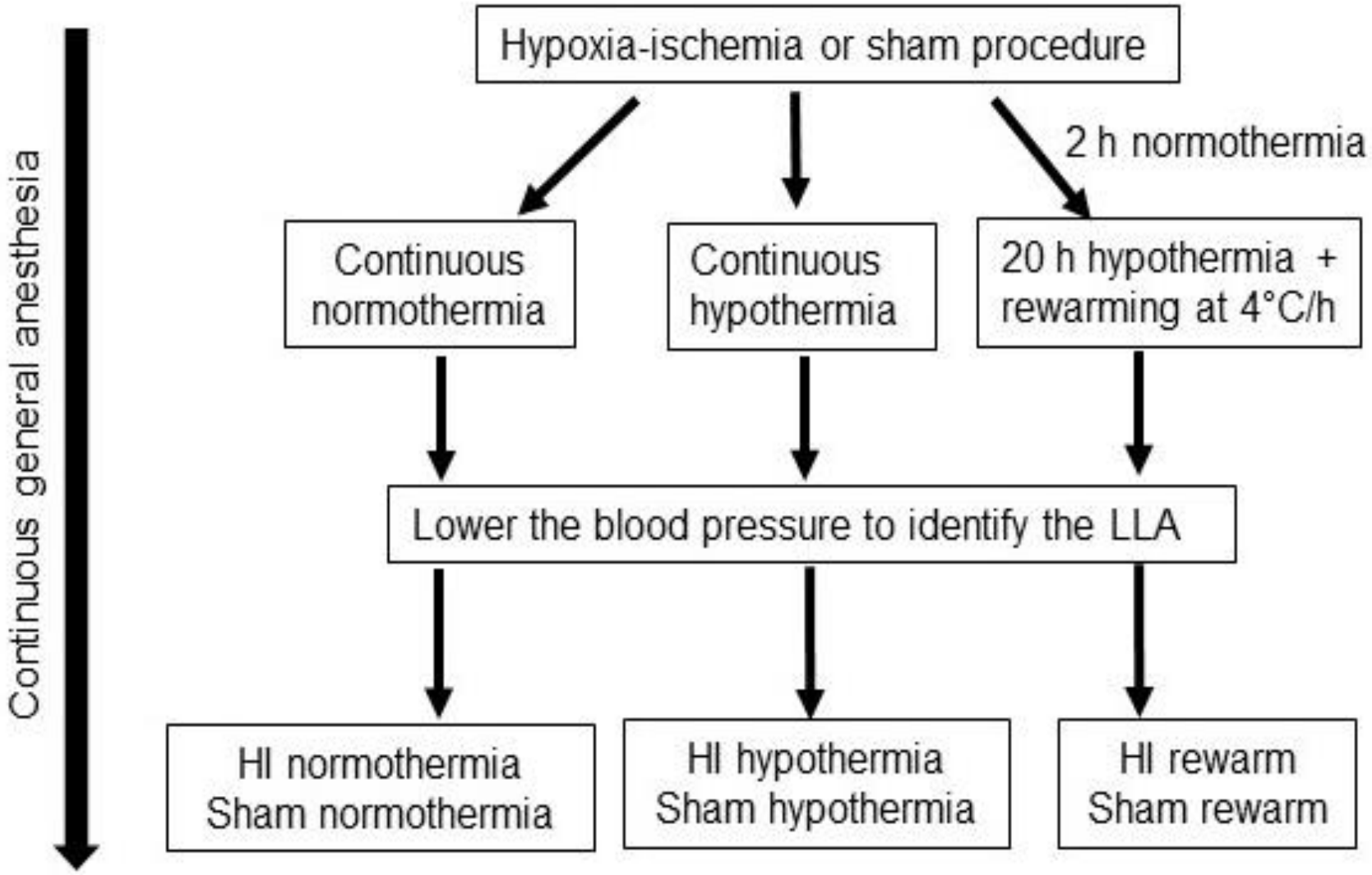
Department of Anesthesia

Division of Pediatric Anesthesia

Piglet hypoxic-ischemic, asphyxic cardiac arrest

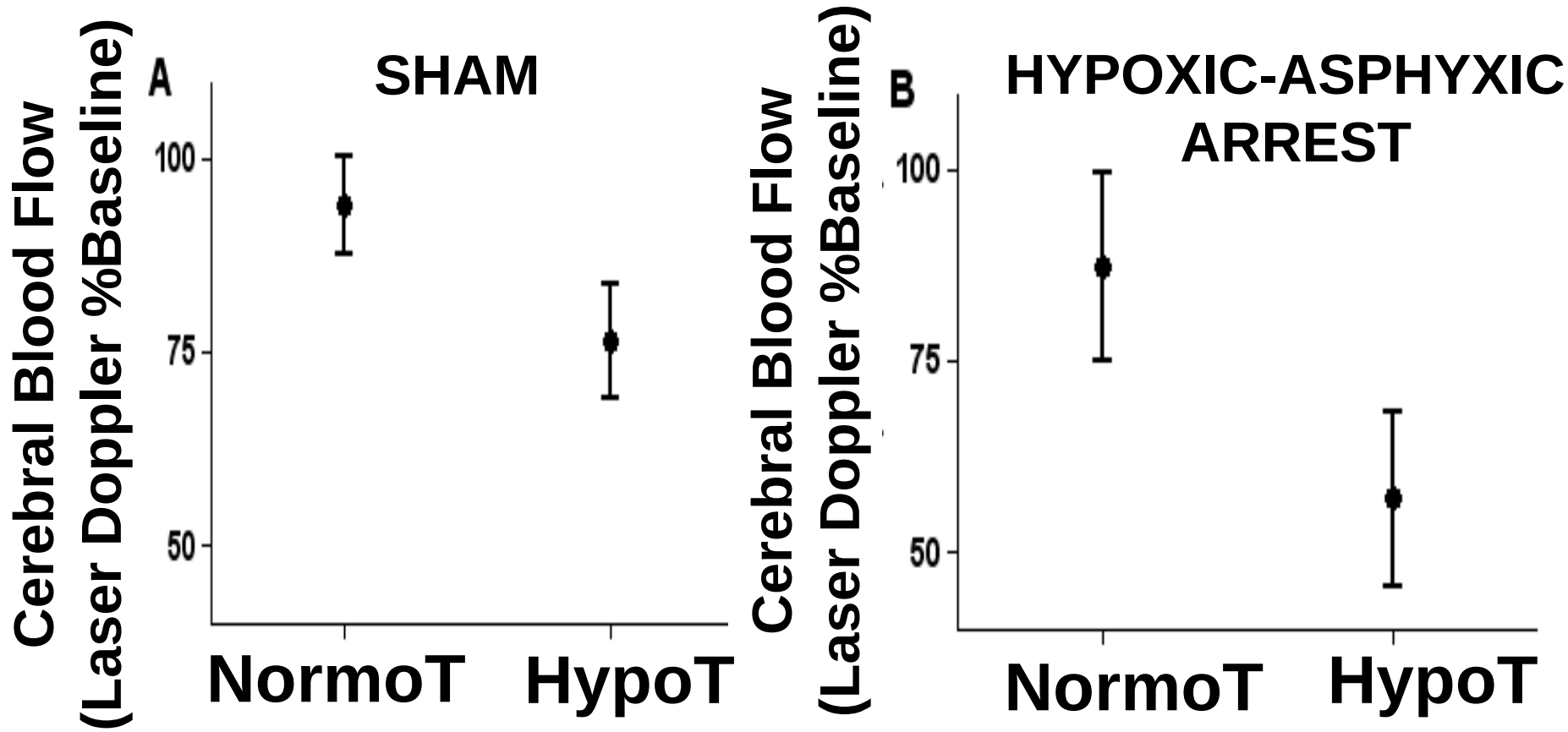
- FiO2 10% for 45 min → clamp endotracheal tube to produce asphyxia for 7 min
- Chest compressions, epinephrine
- Whole body therapeutic hypothermia

Example design: neonatal, male piglets (1-2.5 kg)



- A-line
- ICP monitor
- Laser Doppler flowmetry (CBF)
- NIRS
- Inferior balloon catheter in the inferior vena cava

Hypoxic brain injury ($p = 0.006$) and hypothermia ($p < 0.001$) decrease cerebral blood flow

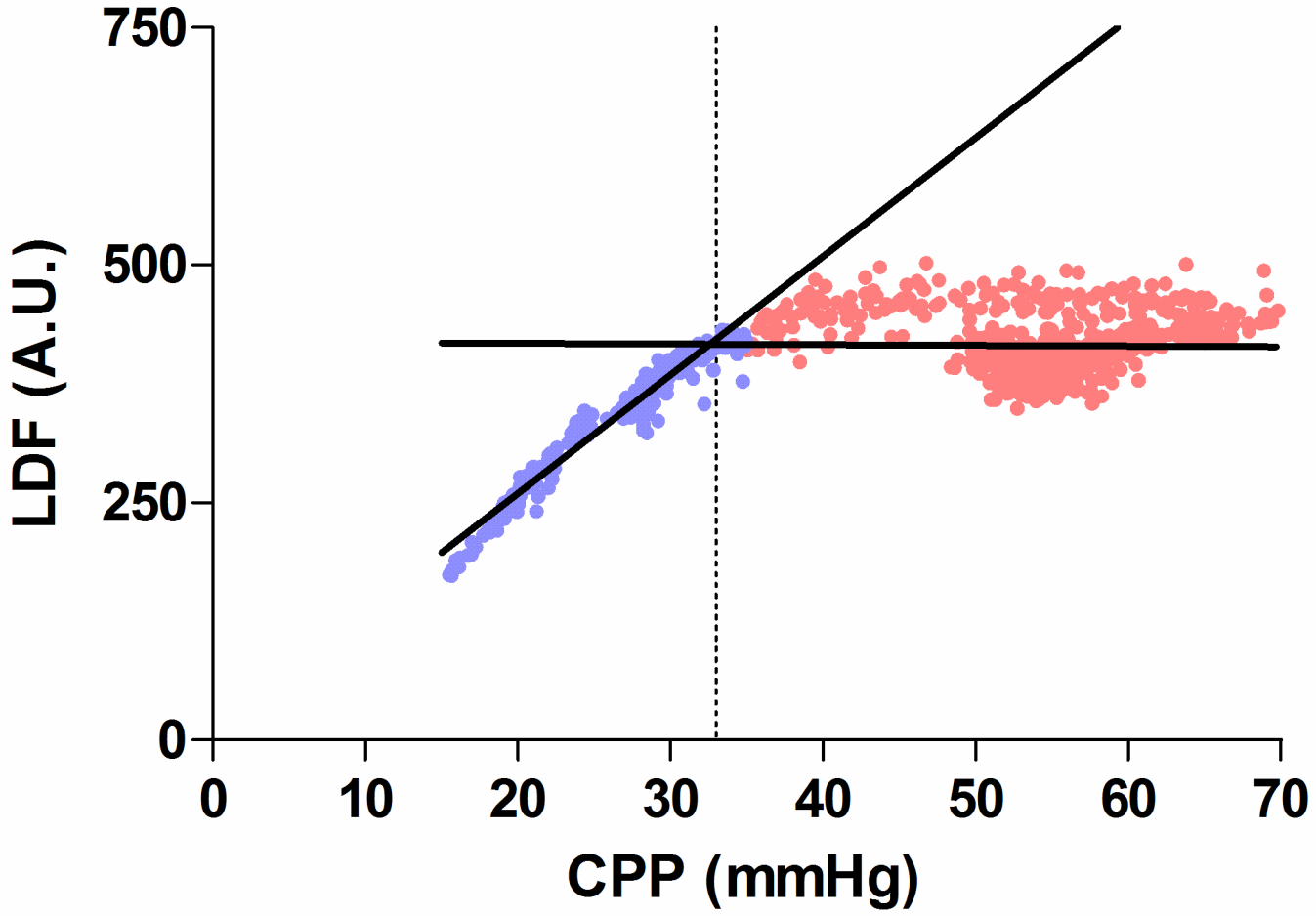


Neonatal piglets underwent sham surgery or hypoxic-asphyxic cardiac arrest (n = 8)

Lee. *CCM* 2011

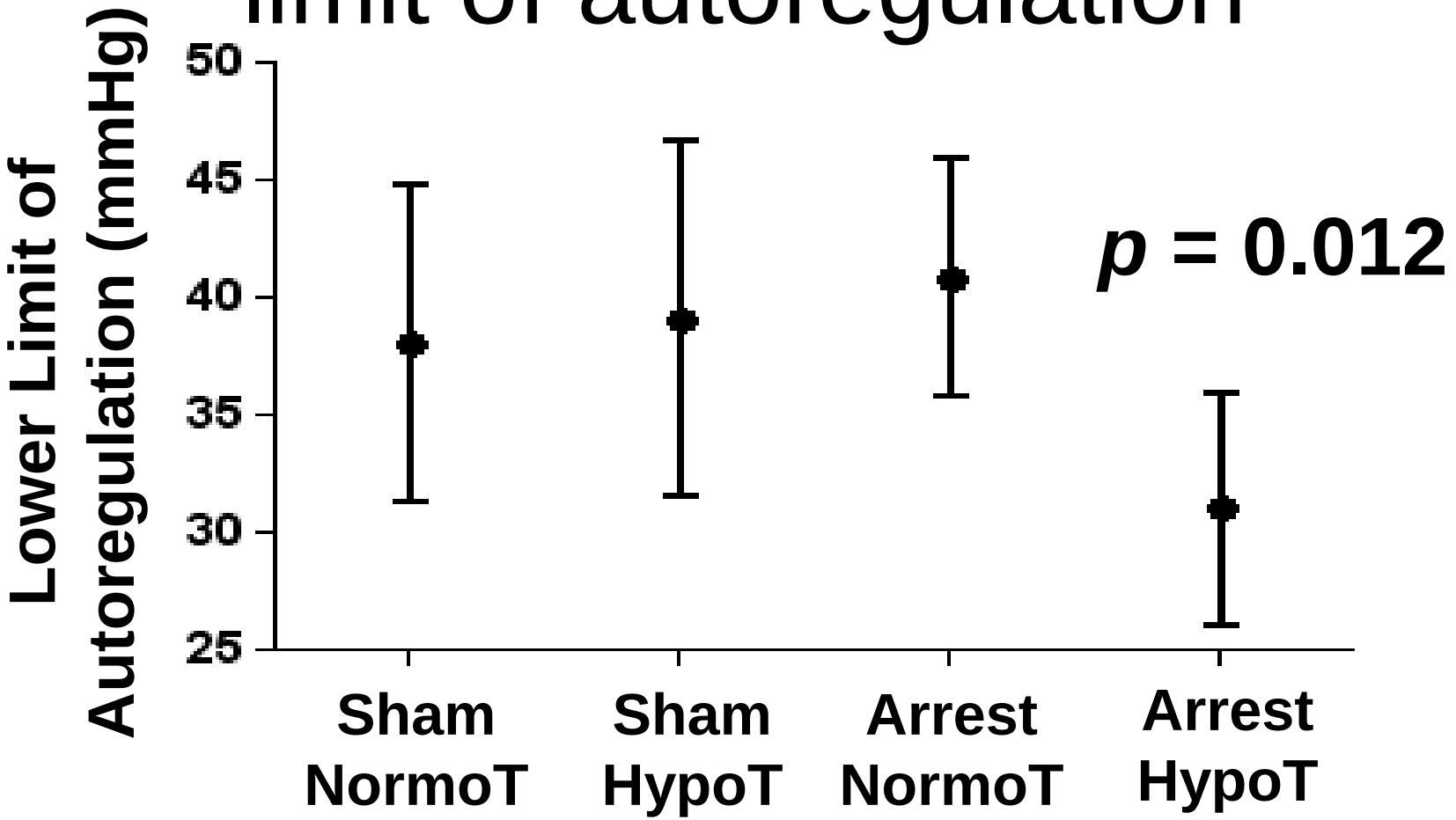
Identifying Limits of Autoregulation

Laser-doppler tracks cerebral blood flow in swine



Lee JK, et al. *Anesth & Analg* 2012

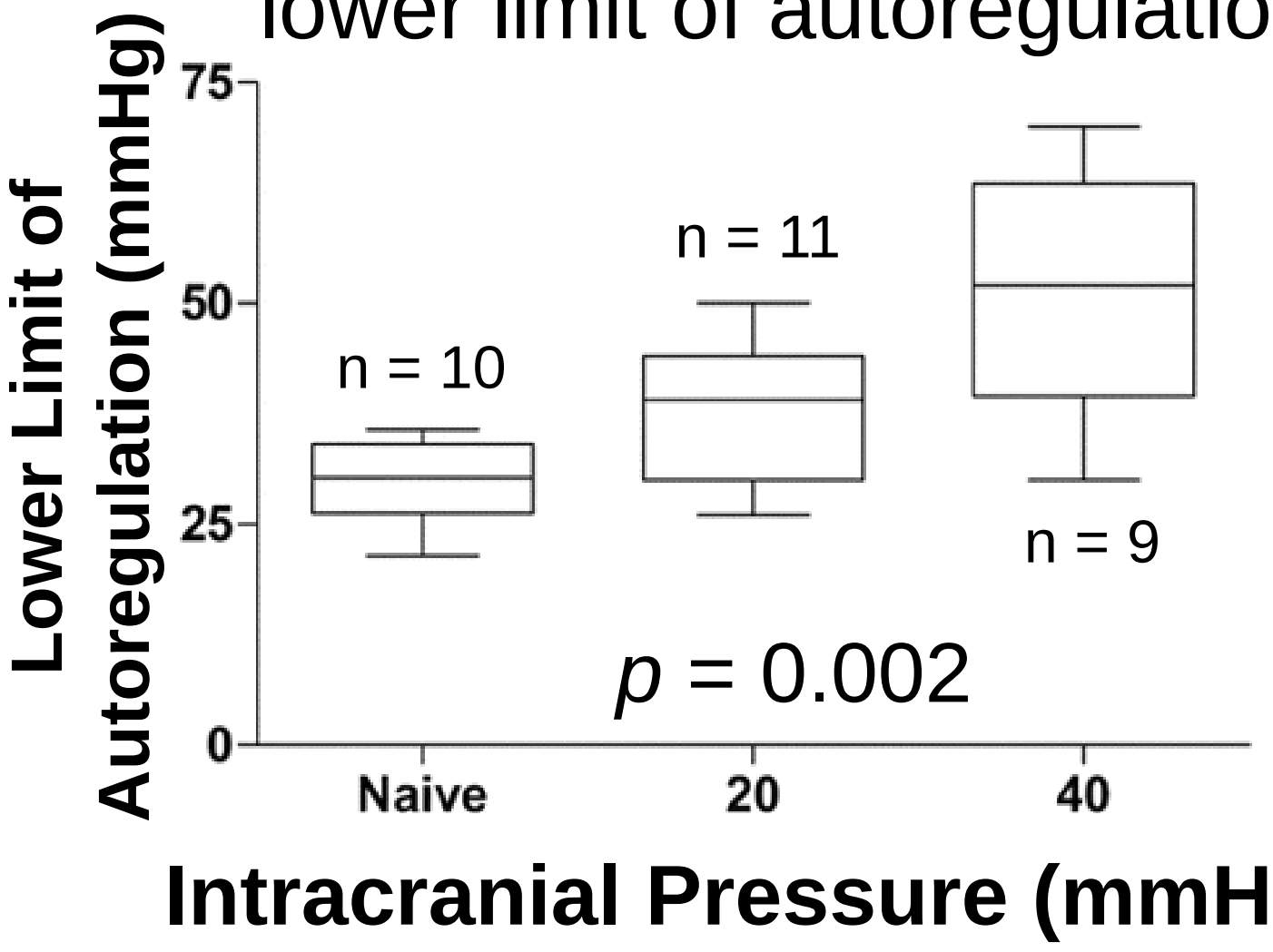
Acute hypothermia may decrease the lower limit of autoregulation



Neonatal piglets underwent sham surgery or hypoxic-asphyxic cardiac arrest (n = 8)

Lee. *CCM* 2011

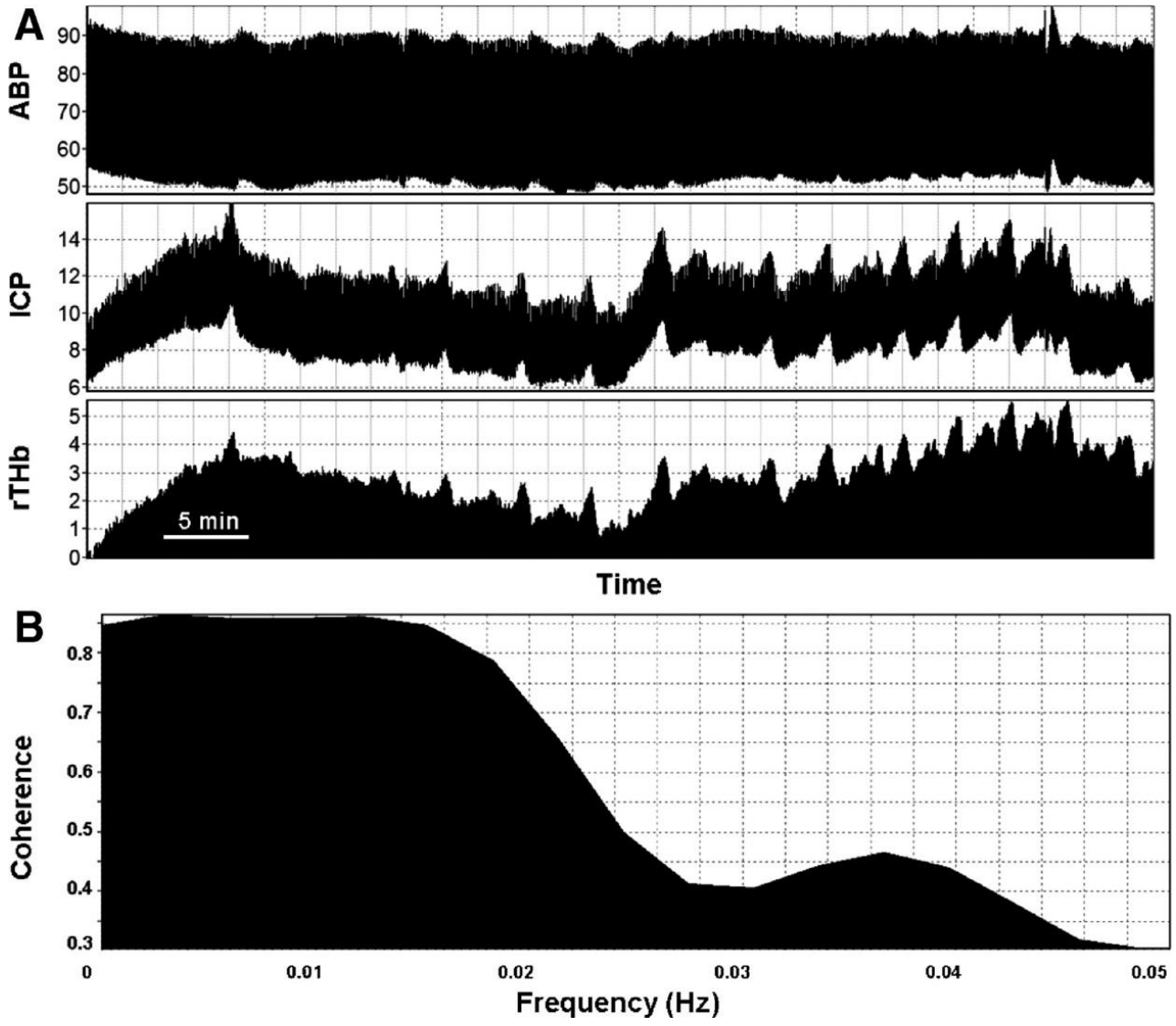
Intracranial hypertension increases the lower limit of autoregulation



Piglet model of controlled hydrocephalus

Brady. *Anesth & Analg* 2009

NIRS and frequency of slow ICP waves



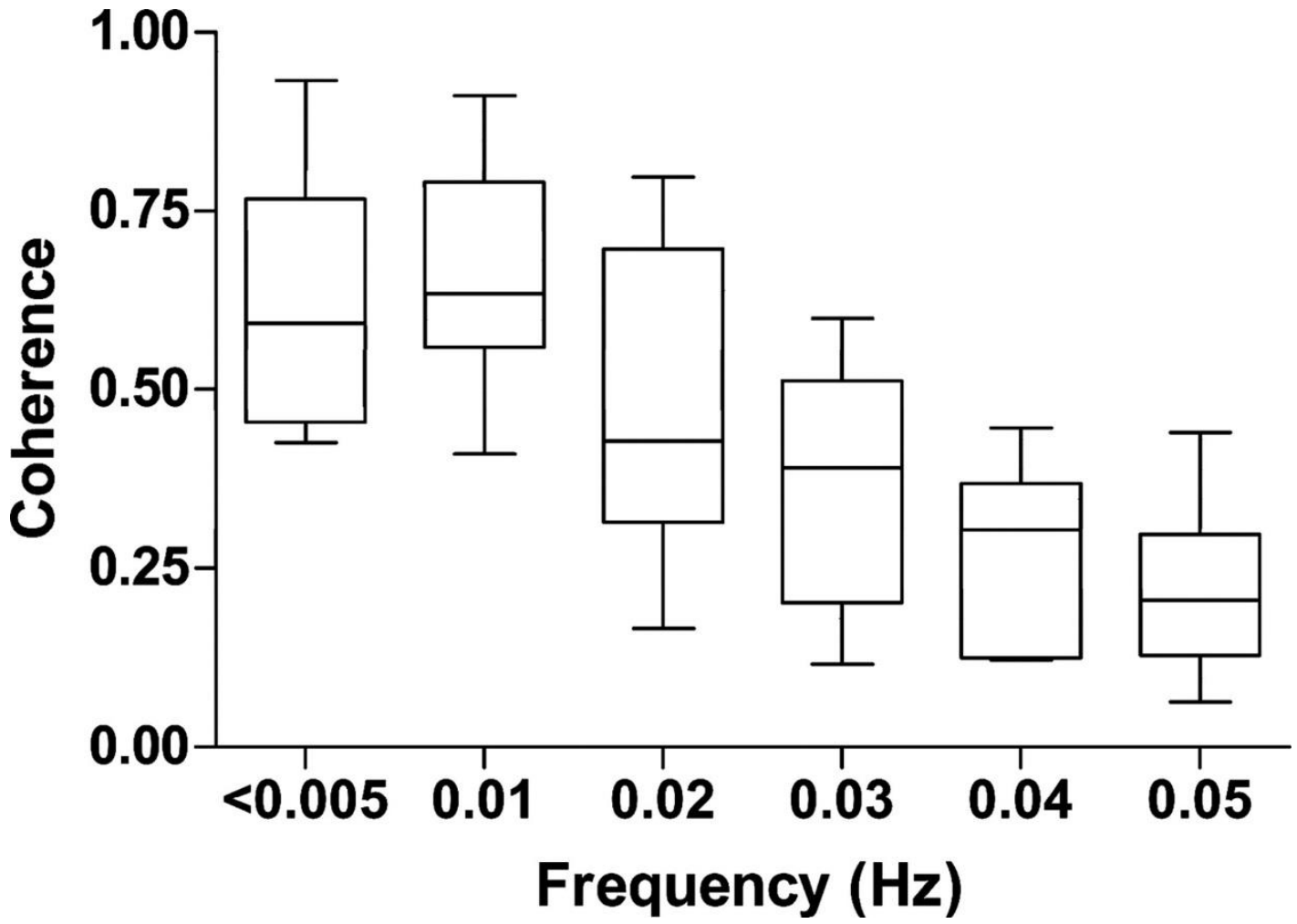
One hour recording period

Slow ICP waves **(0.004 - 0.05 Hz)**

NIRS' relative tissue Hb (rTHb)

Coherence was highest between ICP and NIRS rTHb at frequency of slow ICP waves ≤0.02 Hz

Lee. *Stroke* 2009

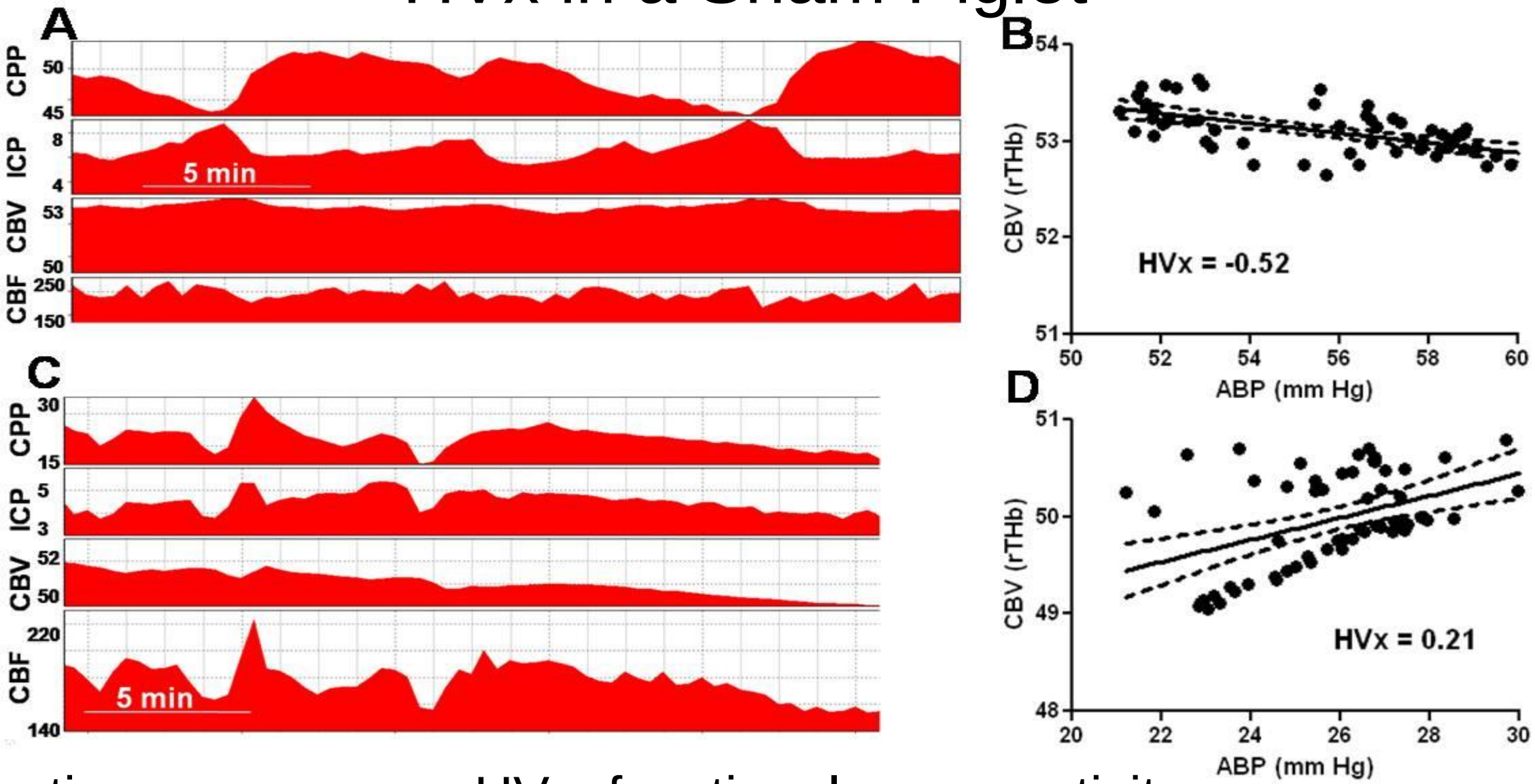


Coherence was high between ICP and NIRS rTHb at frequency of **slow ICP waves (≤0.02 Hz)**

Fluctuations in NIRS' rTHb reflect slow waves changes in ICP and cerebral blood volume during autoregulatory vasoreactivity

Lee. *Stroke* 2009

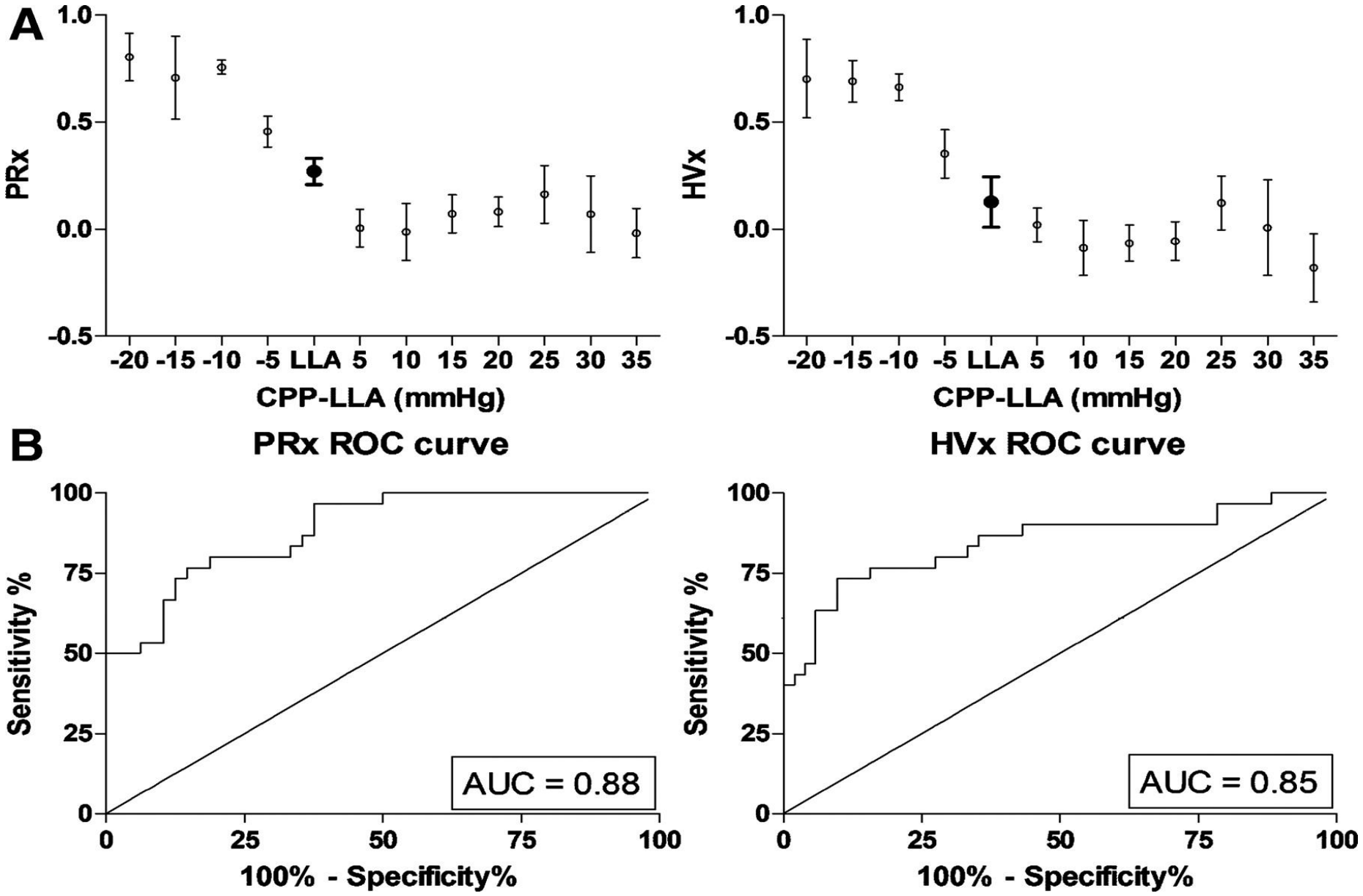
HVx in a Sham Piglet



- Negative or near-zero HVx: functional vasoreactivity
- Positive HVx: impaired vasoreactivity

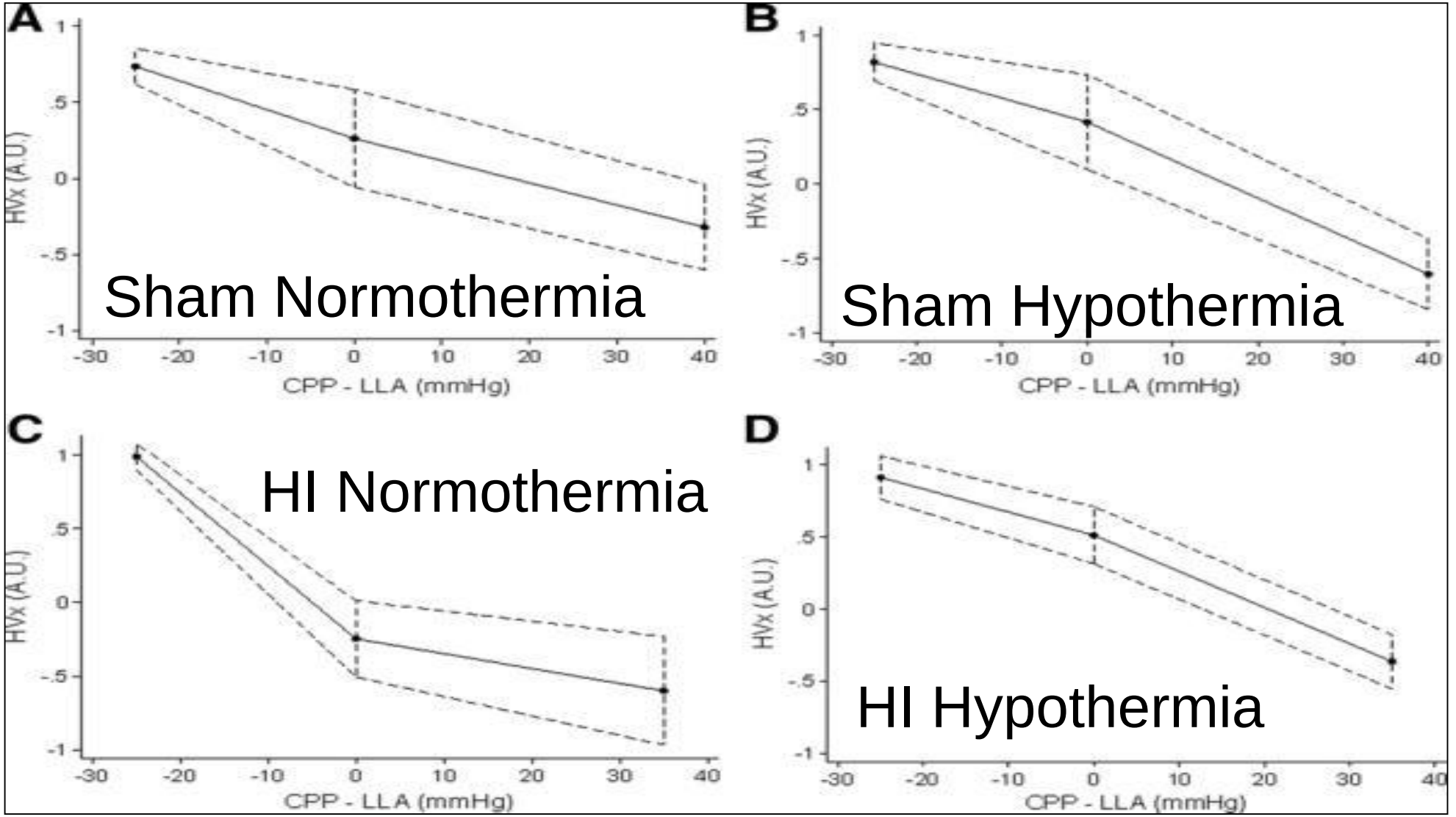
Lee. Stroke 2009

Vasoreactivity Monitoring: PRx and HVx



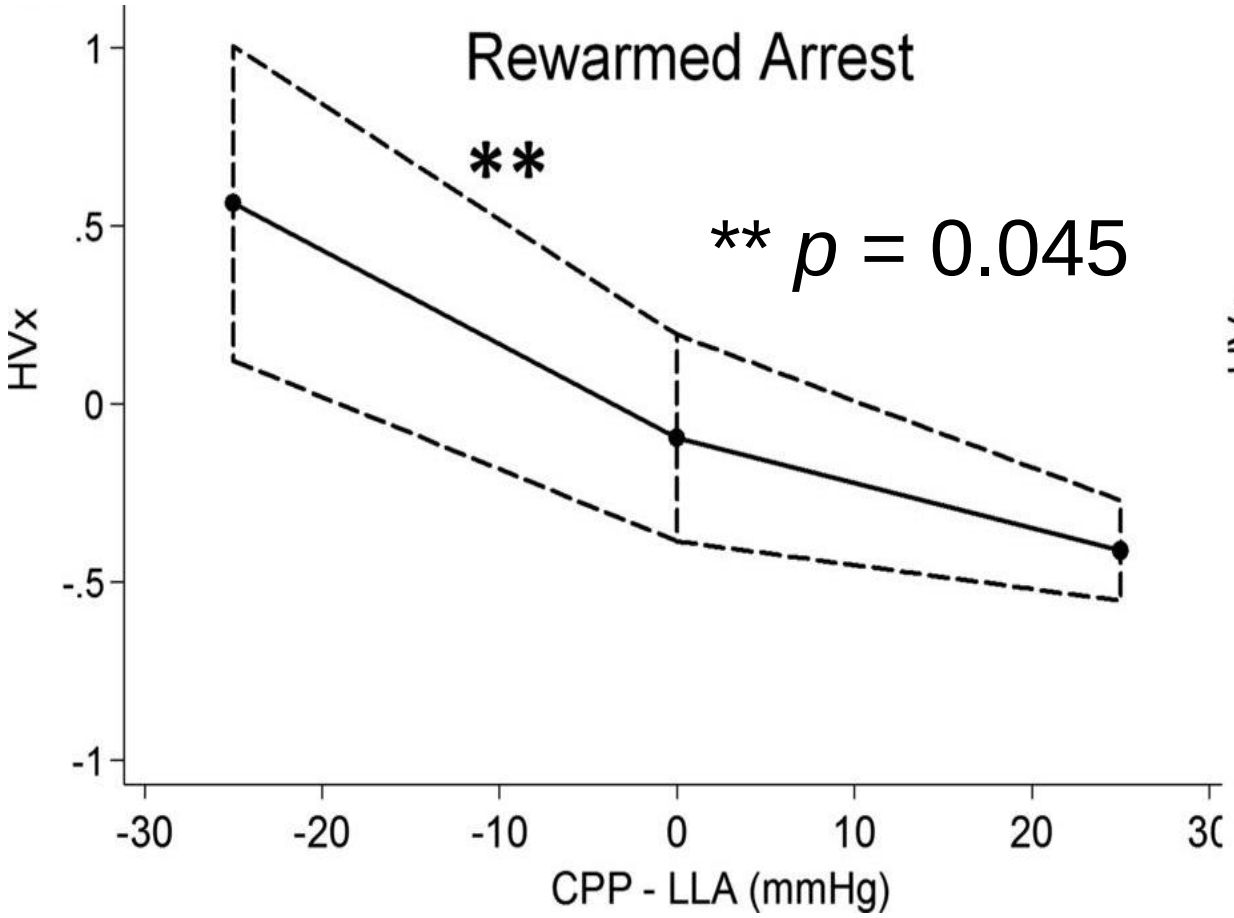
Lee. *Stroke* 2009

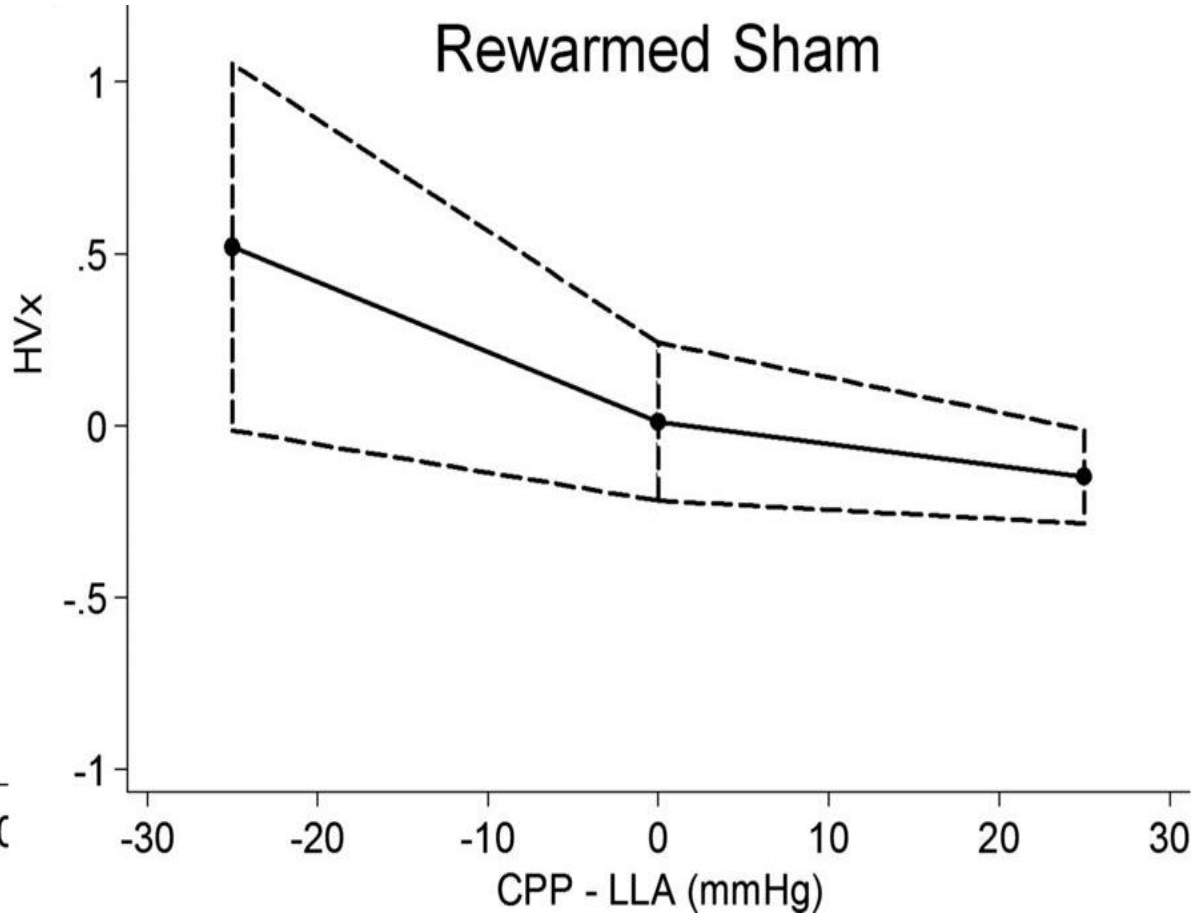
HVx Validation During Hypothermia



Lee. *CCM* 2011.

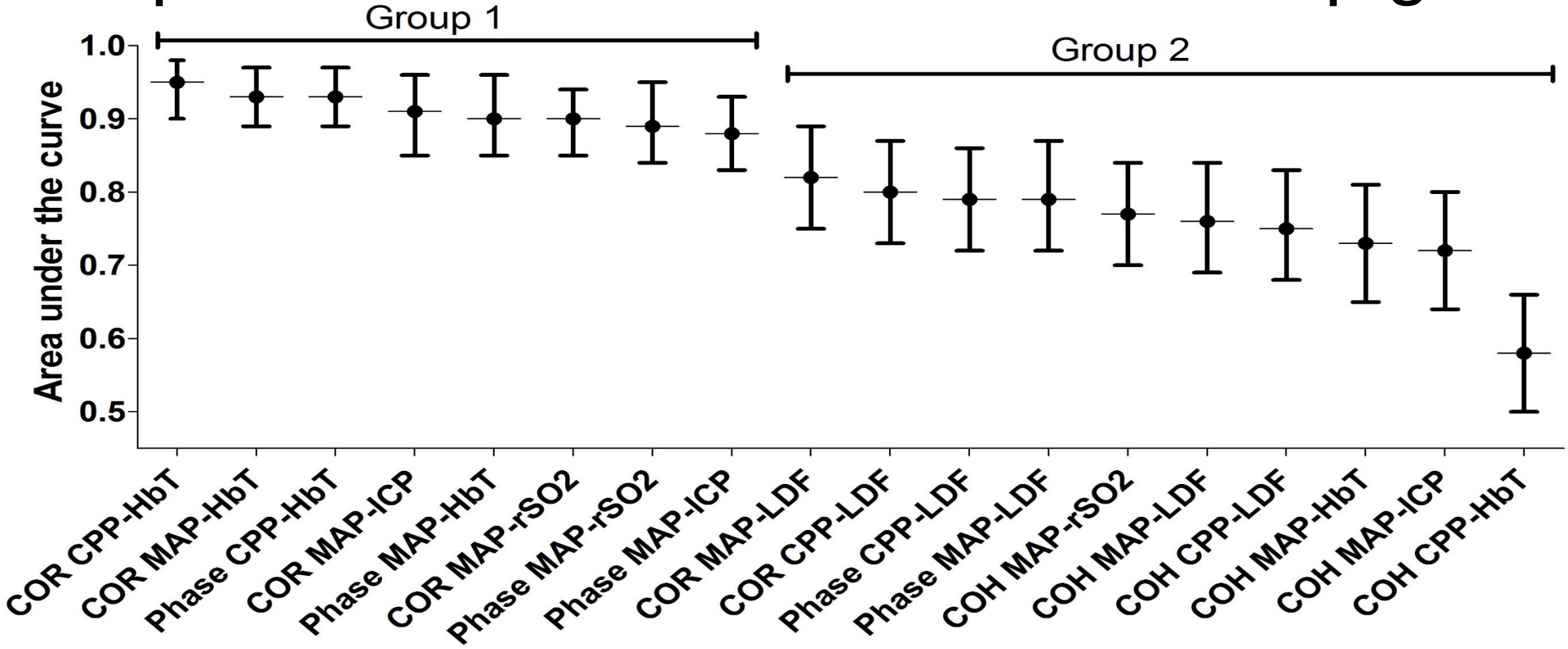
HVx Validation After Rewarming





Larson. *J Appl Physiol* 2013

Comparison of indices: 66 HI or sham piglets



"Phase" = phase shift between the input (MAP, CPP) and output signals (HbT, ICP, rSO2, LDF) using the cross-spectrum at the frequency band with maximum coherence.

Mary Liu, PhD

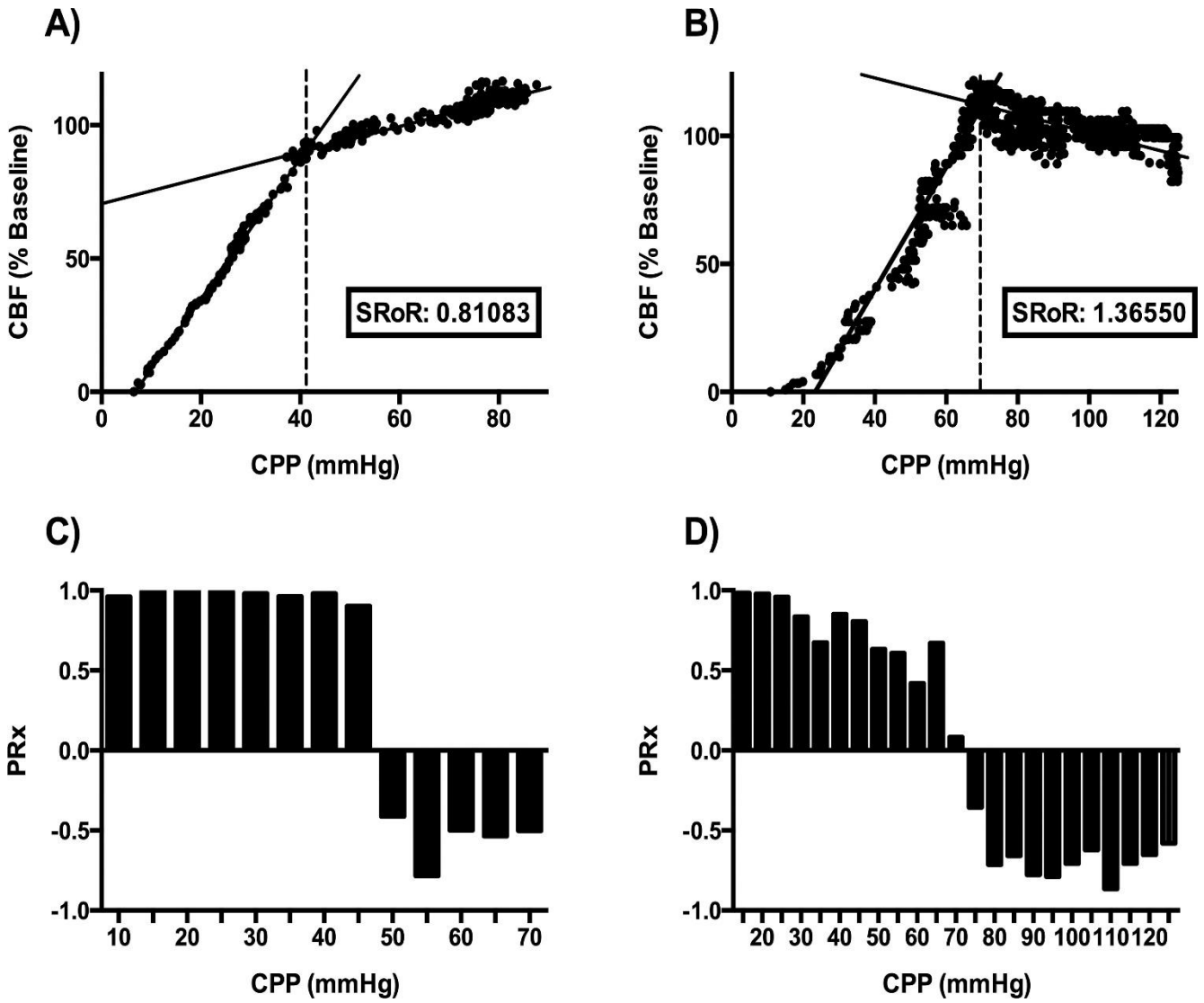
The Journal of Physiology
A Publication of The Physiological Society

Research Paper | Full Access

Wavelet pressure reactivity index: a validation study

Xiuyun Liu ✉, Marek Czosnyka, Joseph Donnelly, Danilo Cardim, Manuel Cabeleira, Peter J. Hutchinson, Xiao Hu, Peter Smielewski, Ken Brady

Static Rate of Autoregulation (SRoR): the plateau



SRoR = %∆CVR/ %∆CPP

SRoR 1 = perfect autoregulation

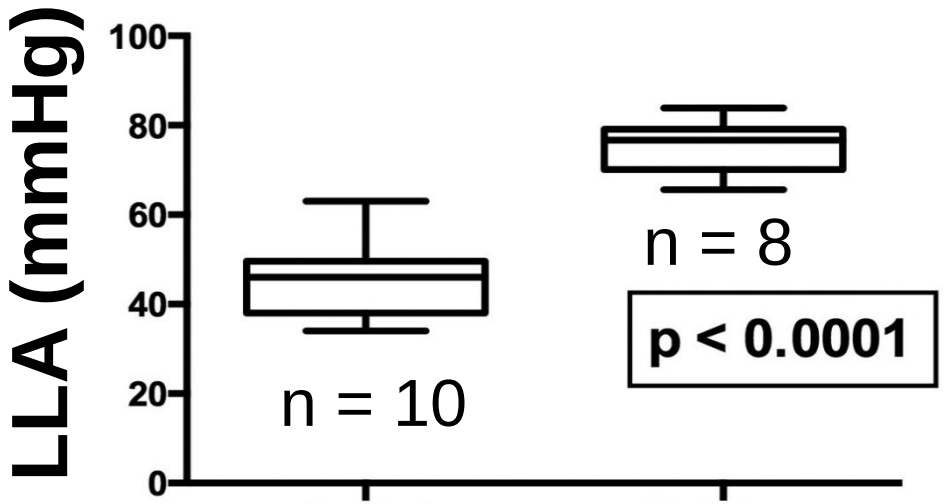
SRoR <0.5 = dysfunctional autoregulation

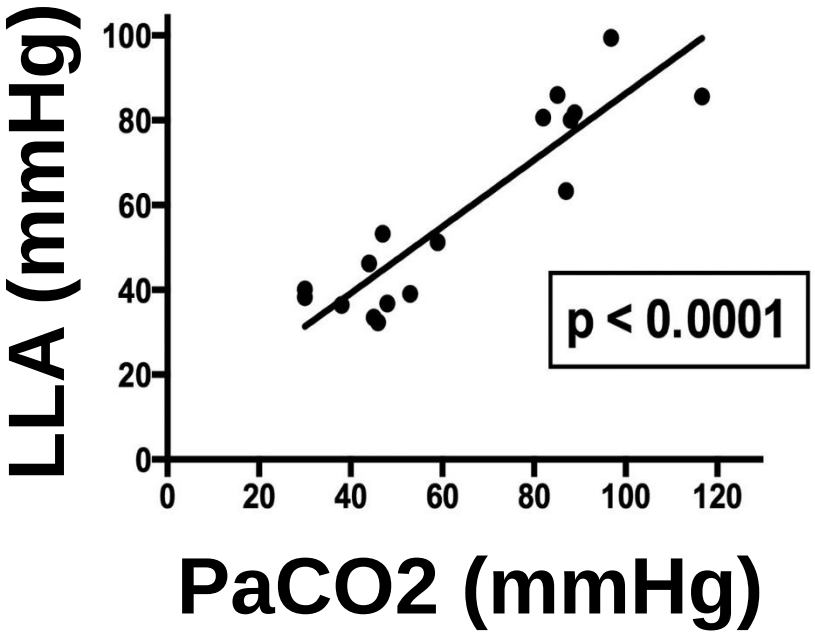
SRoR >1 = CBF increases as CPP decreases

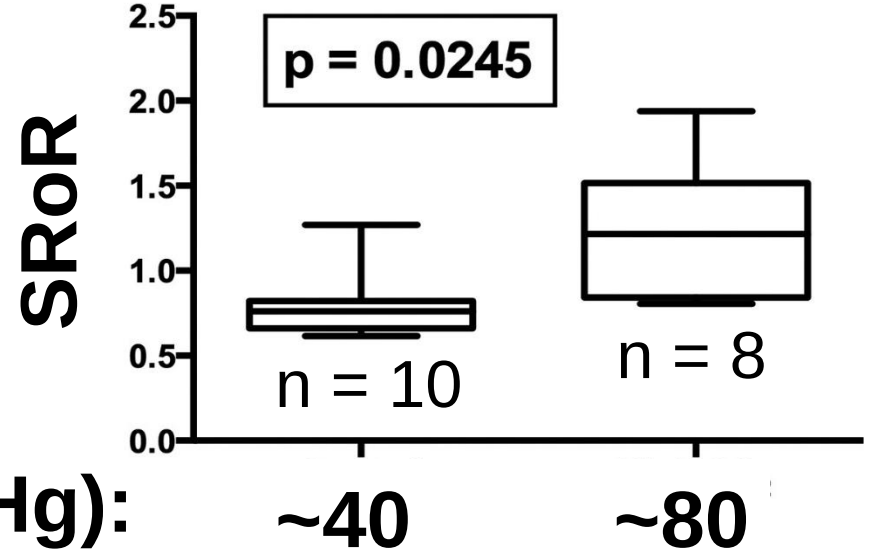
SRoR <0 = vessels collapse or passively distend with changes in CPP

Nusbaum. *Neurol Res* 2016

Hypercarbia







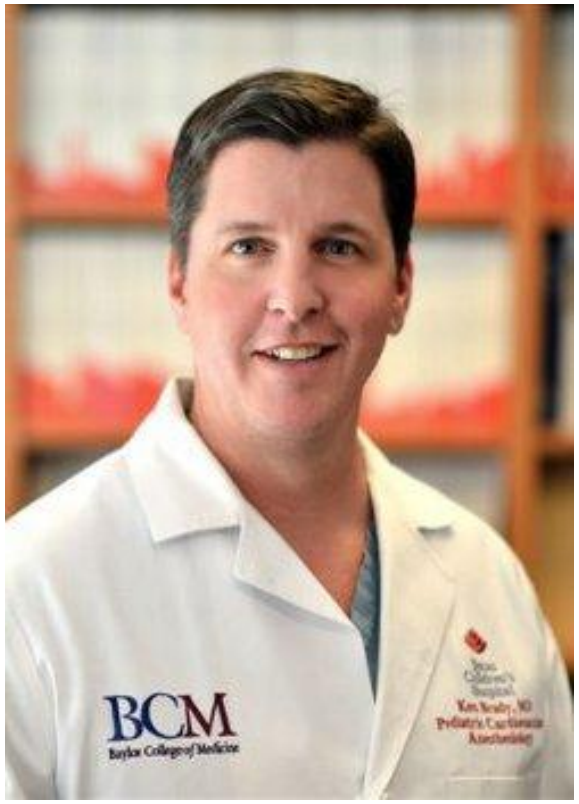
Normocarbia: mean ICP 11 – 12 mmHg

Hypercarbia: mean ICP 10 -14 mmHg

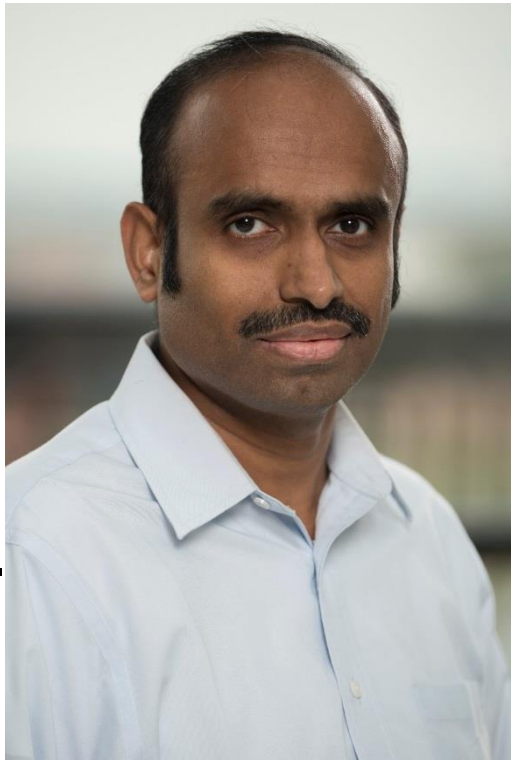
Nusbaum. *Neurol Res* 2016

Raymond Koehler, Ph.D.

Lee Martin, Ph.D.



Ken Brady, M.D.



R.B. Govindan, Ph.D.