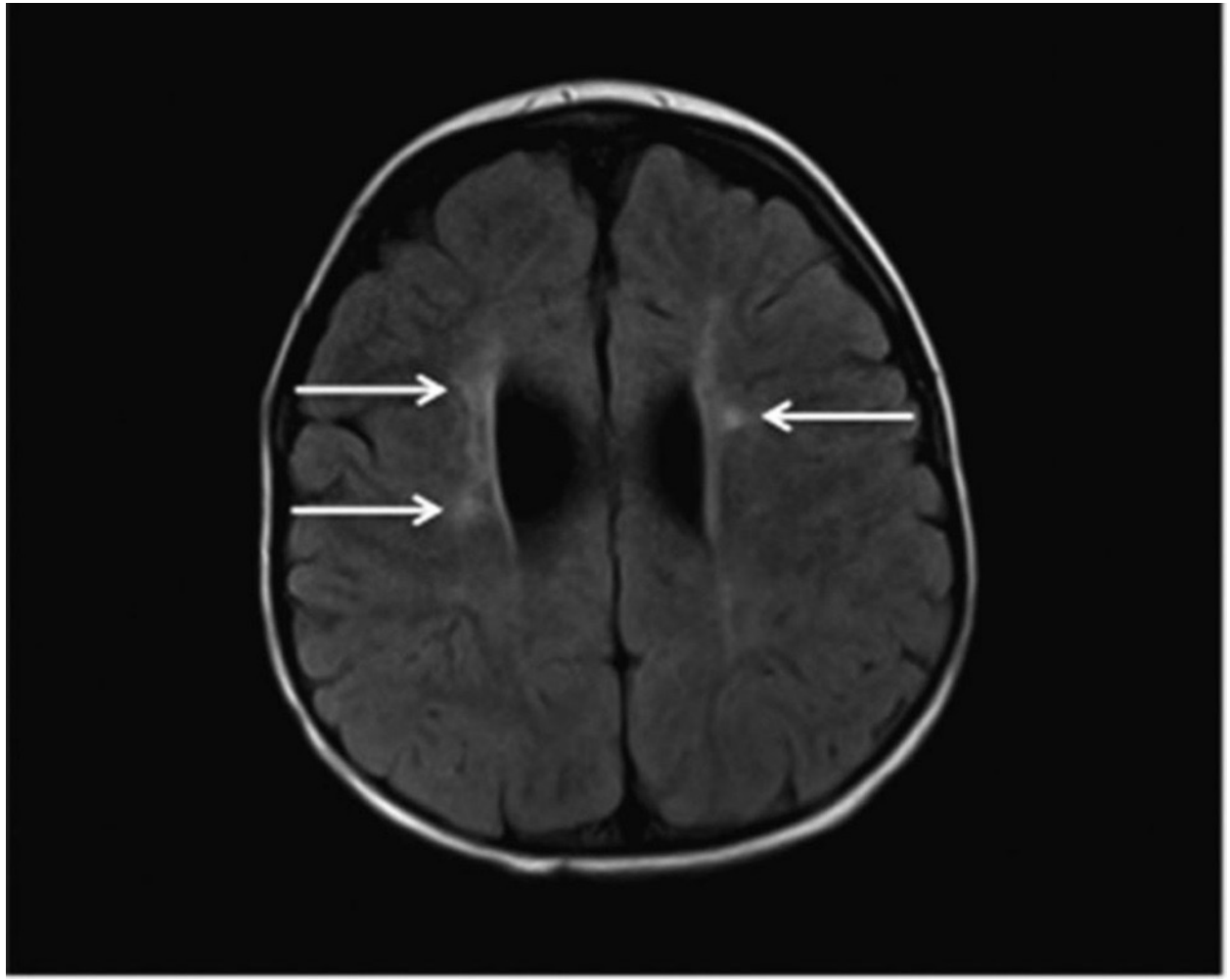
Warm and well perfused?

Neuromonitoring in Stage I

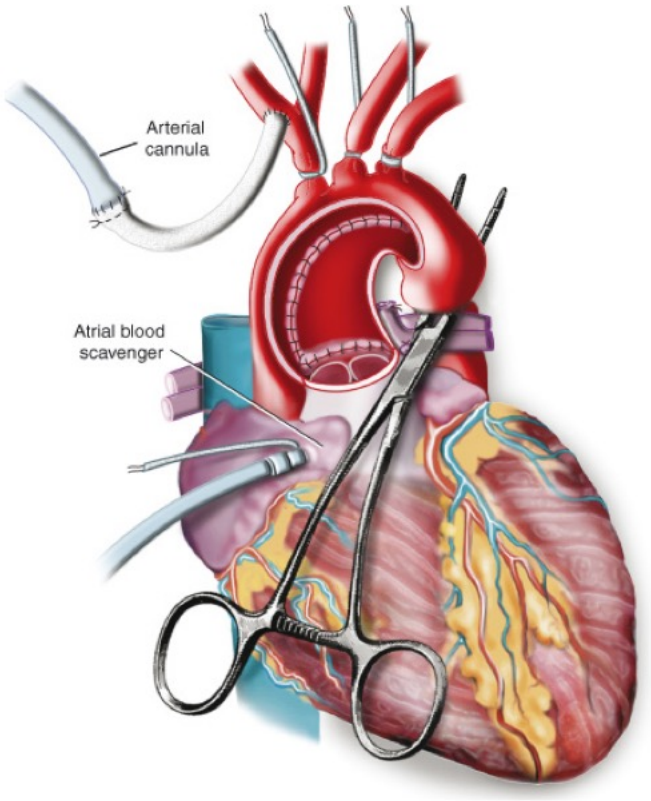
- Does perioperative management contribute to neurologic injury in Stage I patients?
- How is the brain perfused differently than other organs?
- Is there a safe way to do selective perfusion?

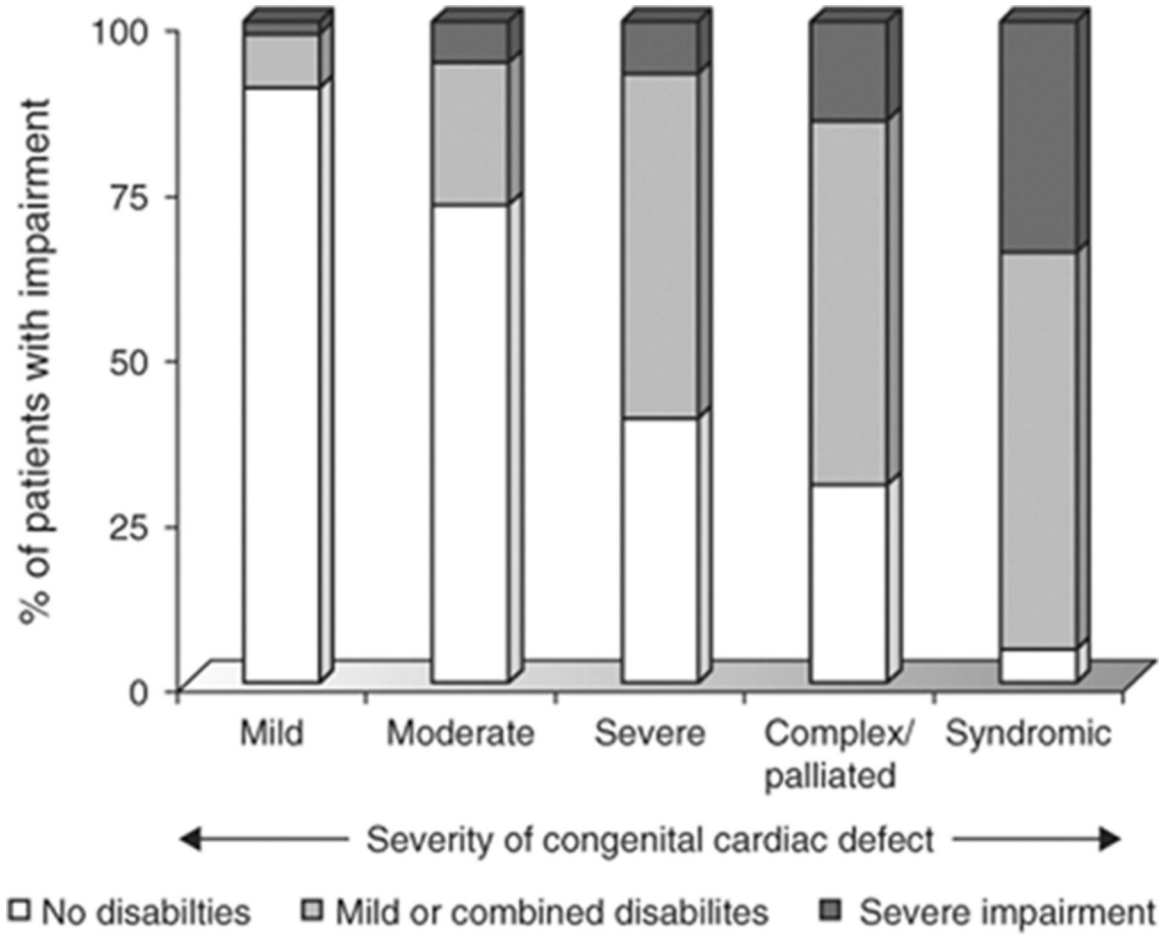

No disclosures

Half of neonates with critical heart disease suffer neurologic injury



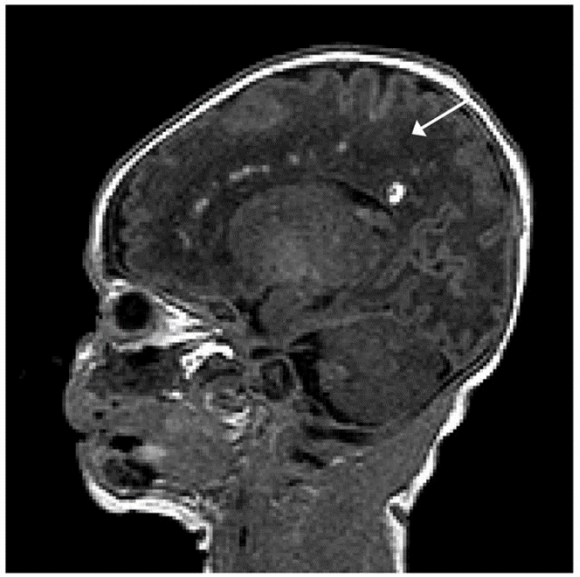
Increased surgical complexity = decreased I.Q.

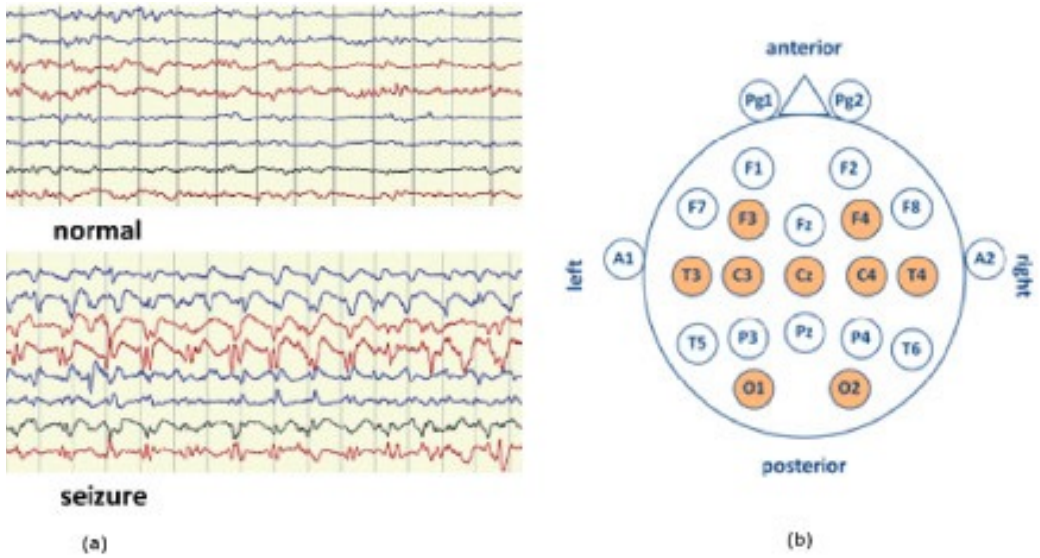




Seizure after neonatal cardiac surgery

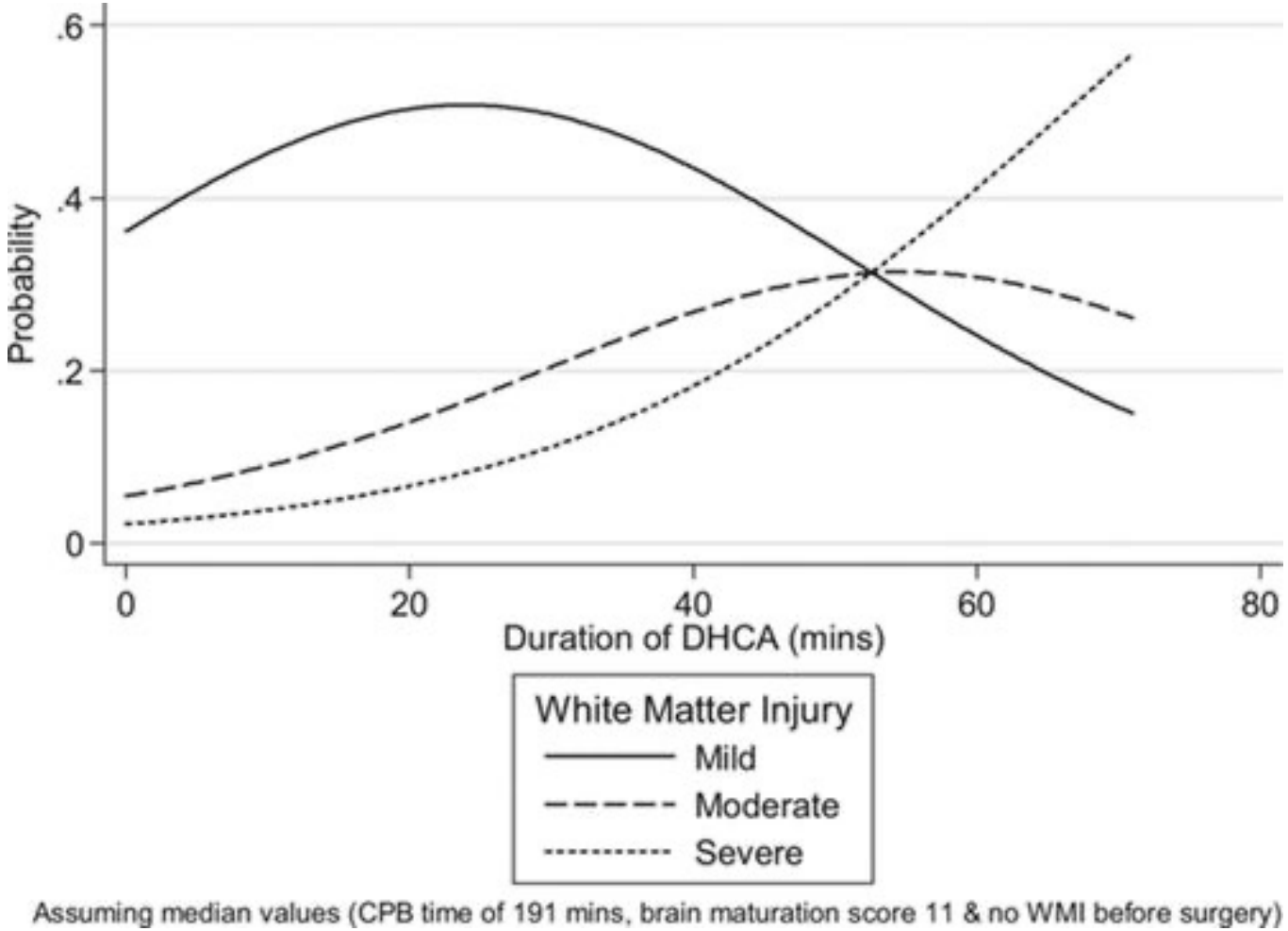
- 8% of 739 neonates had seizure after CPB
- Full montage recording
- 85% clinically silent
- Associated with death
  - 27% with seizure died vs. 5% without seizure died





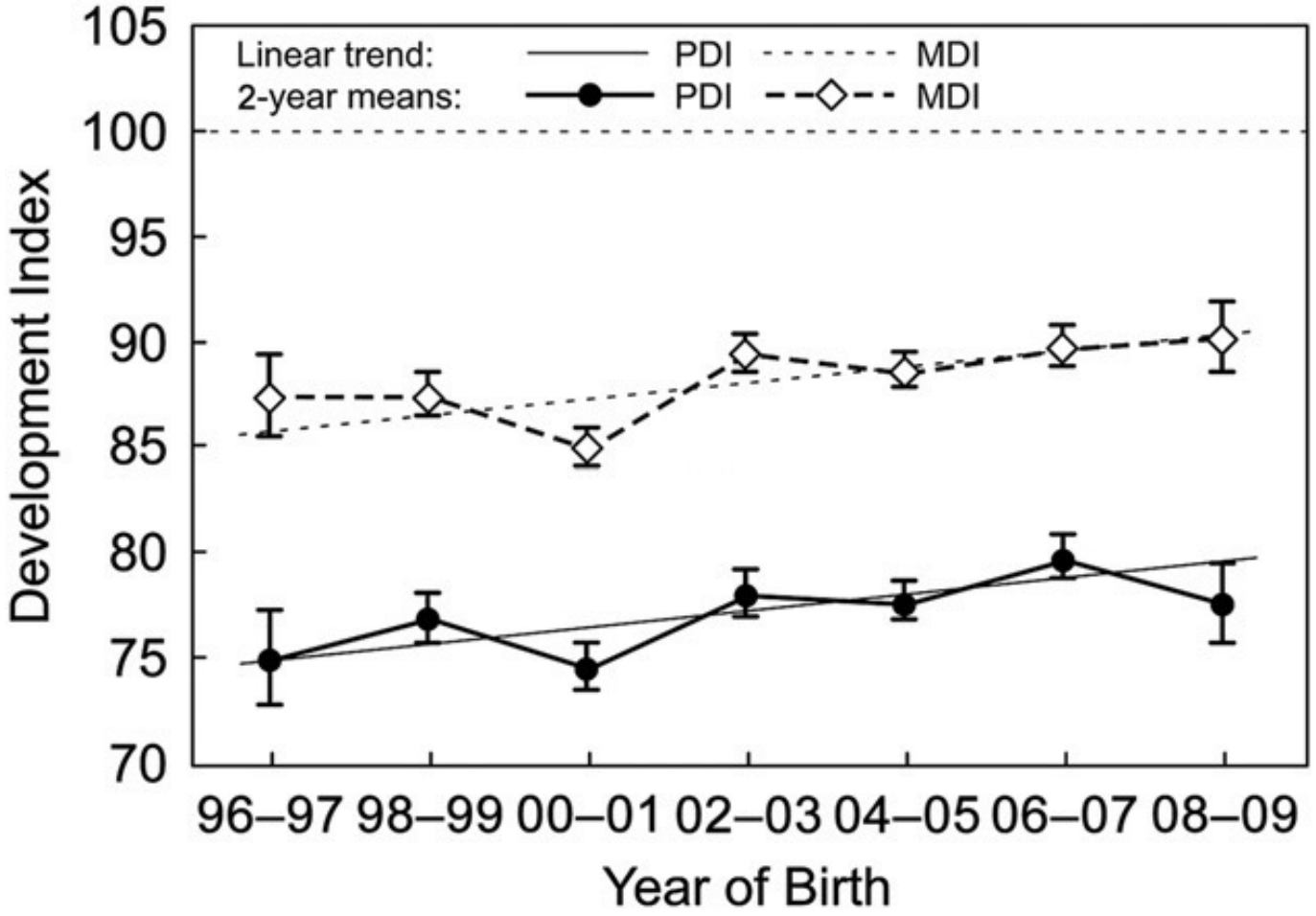
Naim et al, Presented Nov 2019 AHA meeting in Philadelphia

Modifiable?



Beca, Shekerdemian et al. Circulation 2013.

Not Modifiable?

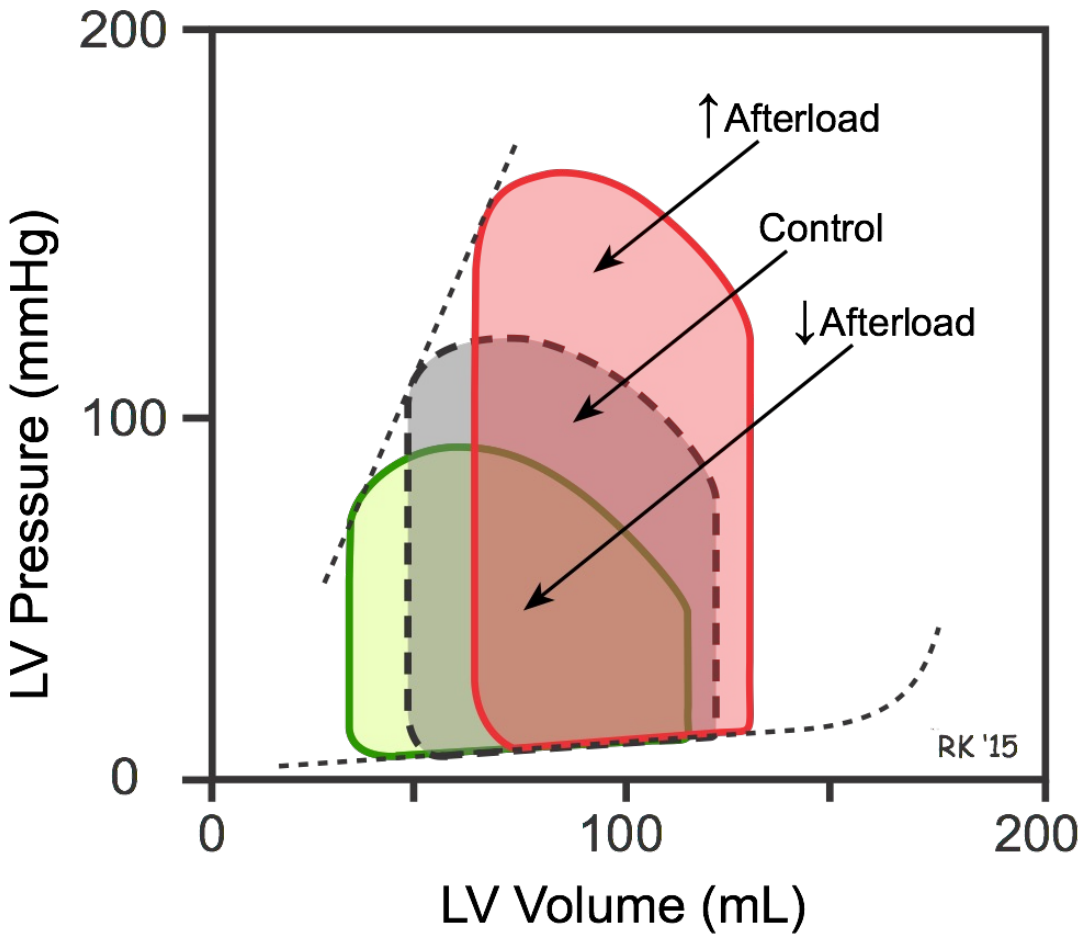


William Gaynor, Pediatrics 2015

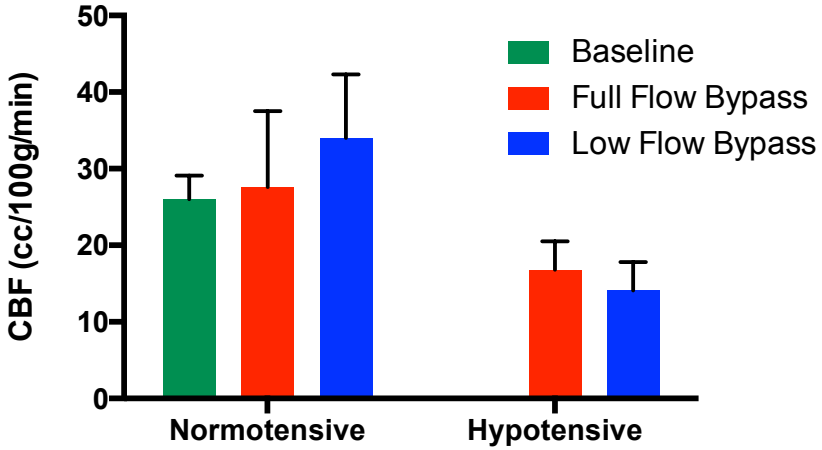
I. The difference between cerebral and renal perfusion

What we learned about neonatal afterload in the 1990's

- Smaller stroke volume
- Less cardiac output
- Less visceral perfusion
- Higher Qp/Qs
- Tissue acid production
- Higher end-diastolic pressure
- More cardiac wall strain
- More post-op cardiac arrests



CBF is dependent on ABP, not cardiac output



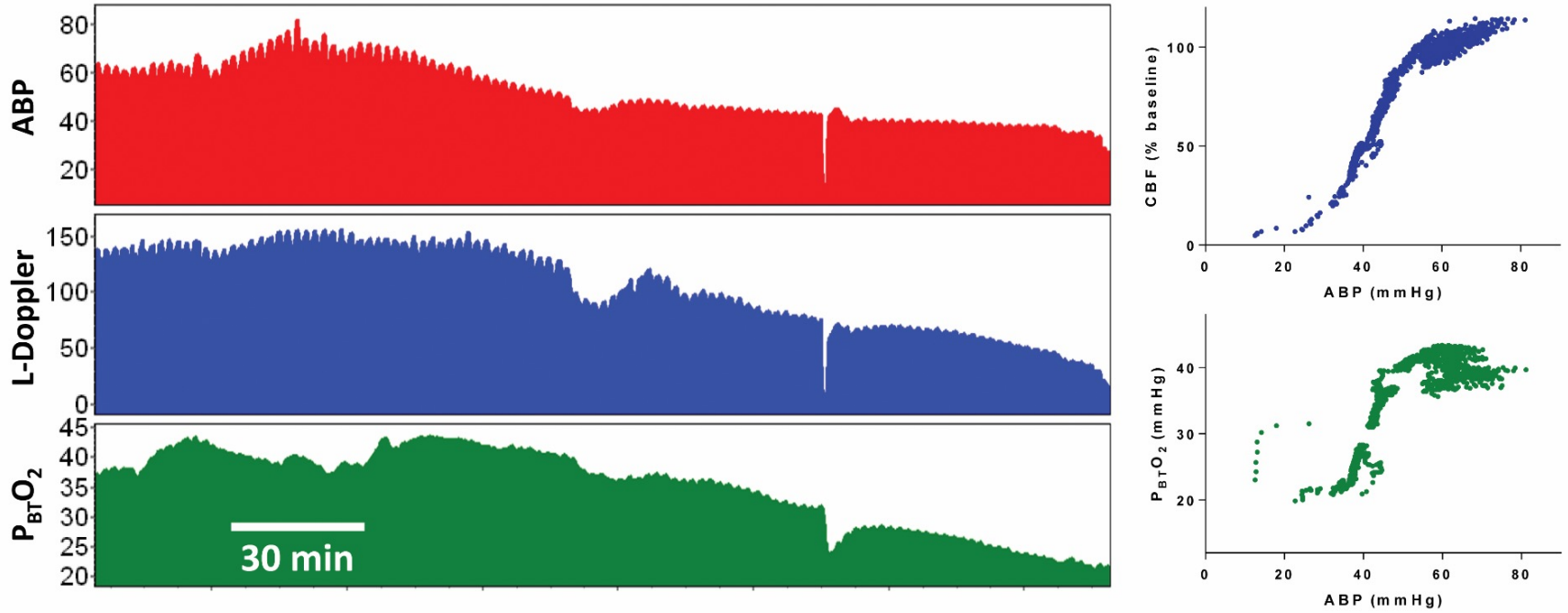
Basic neurosurgical doctrine

Not part of the cardiac lexicon

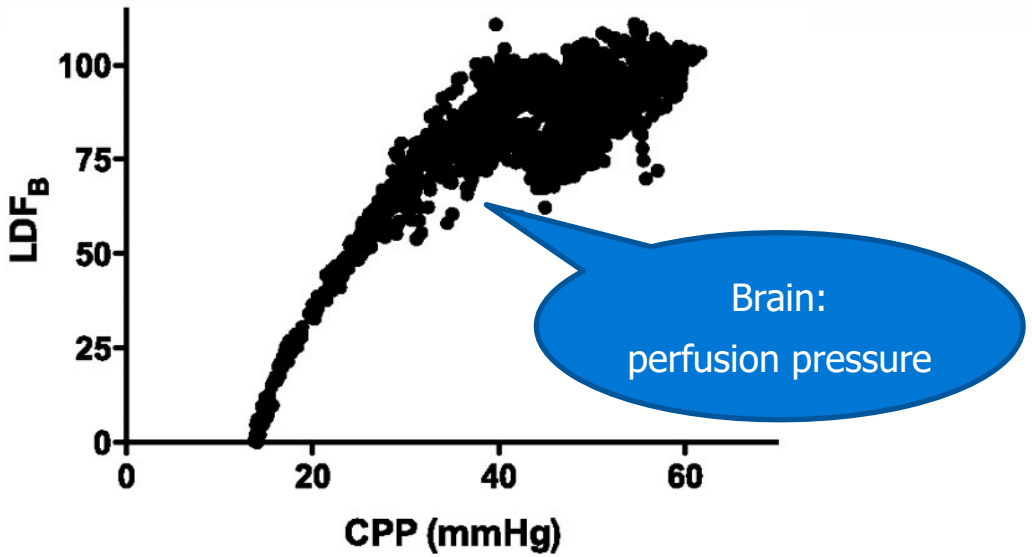
Data shown are baboons on CPB

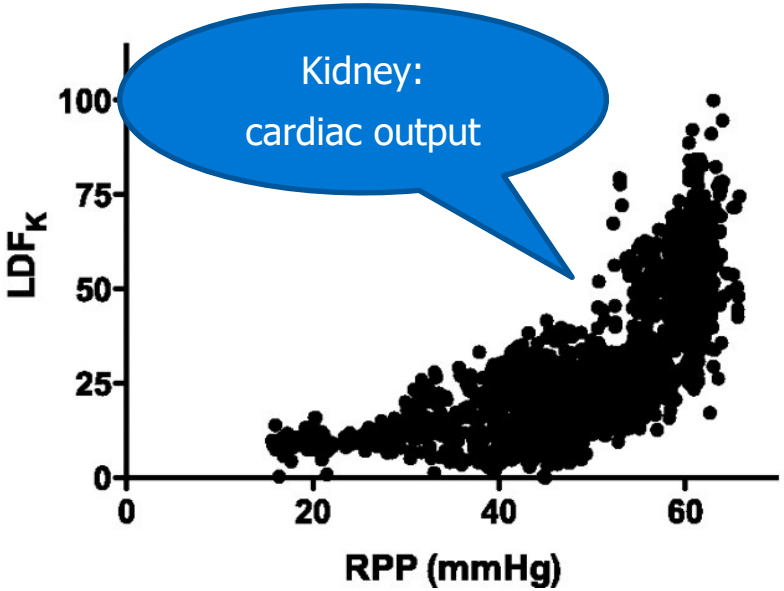
Schwartz et al Ann Thorac Surg 1995

Full flow does not protect the brain without pressure



Renal blood flow is dependent on cardiac output





- Hemorrhagic shock induced in neonatal piglets
- CBF does not fall *until* ABP falls
- RBF falls *before* ABP falls

Do I choose brain or kidney injury?

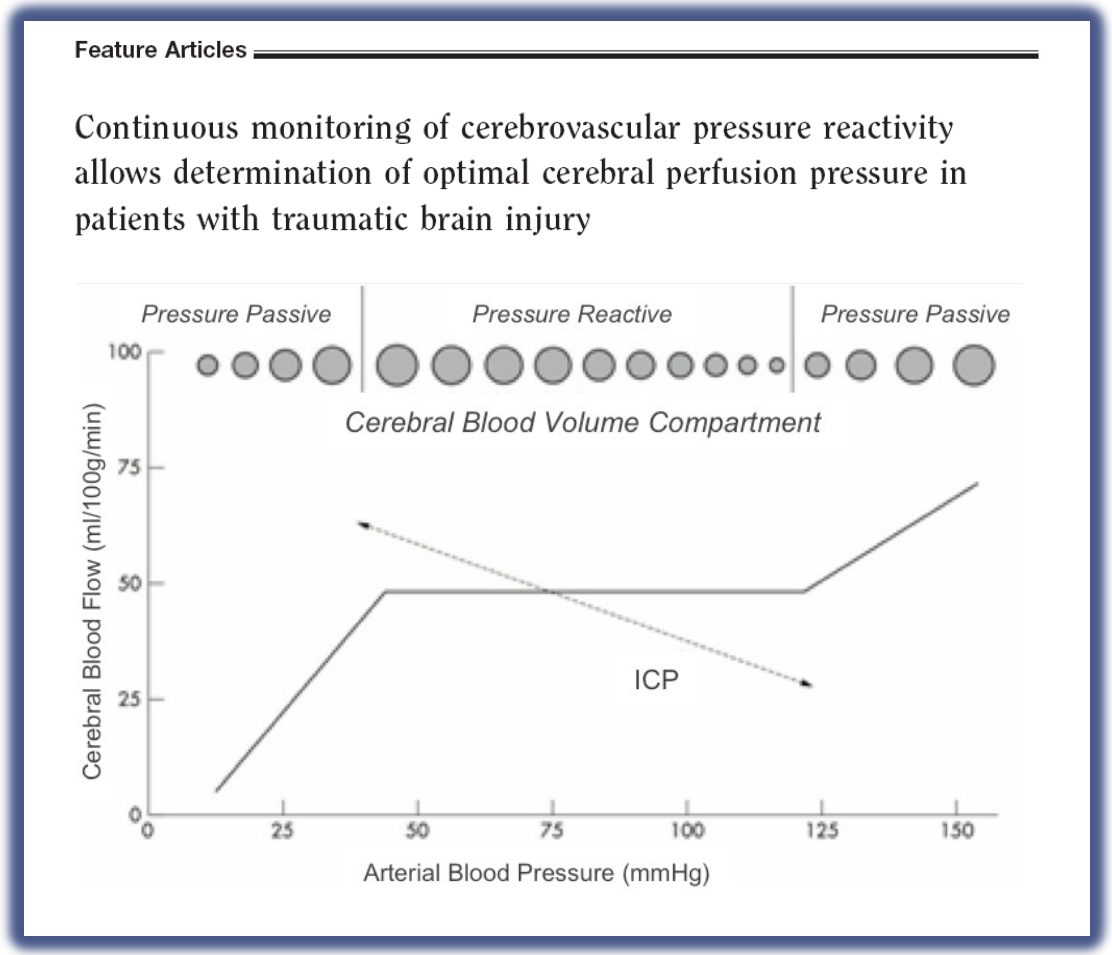
Cerebral and Renal vascular beds respond differently to low output and low pressure.

Afterload reduction improves cardiac output and renal perfusion.

Afterload reduction does not improve perfusion to the brain.

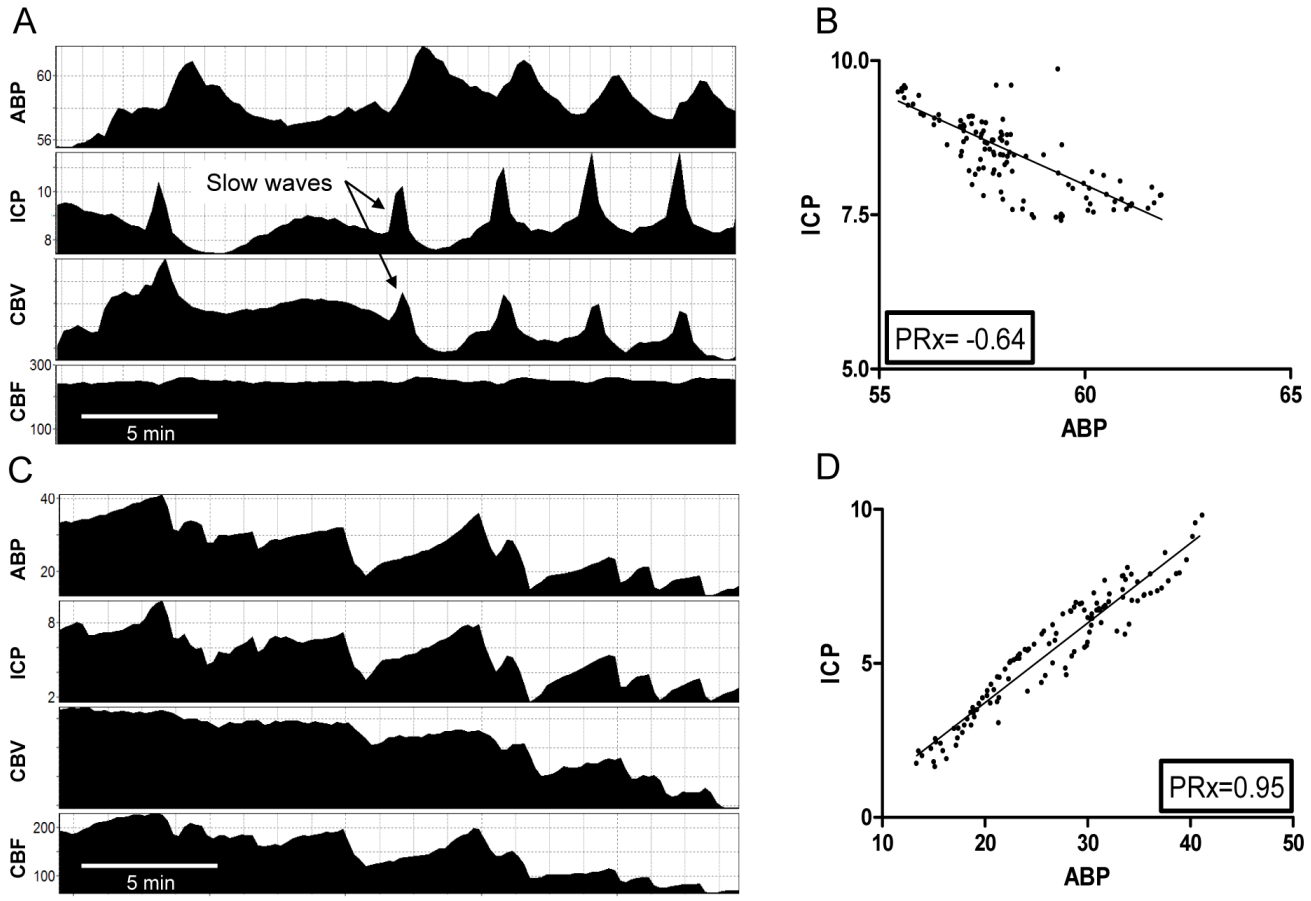
II. What is autoregulation monitoring?

The Cambridge Hypothesis: finding LLA

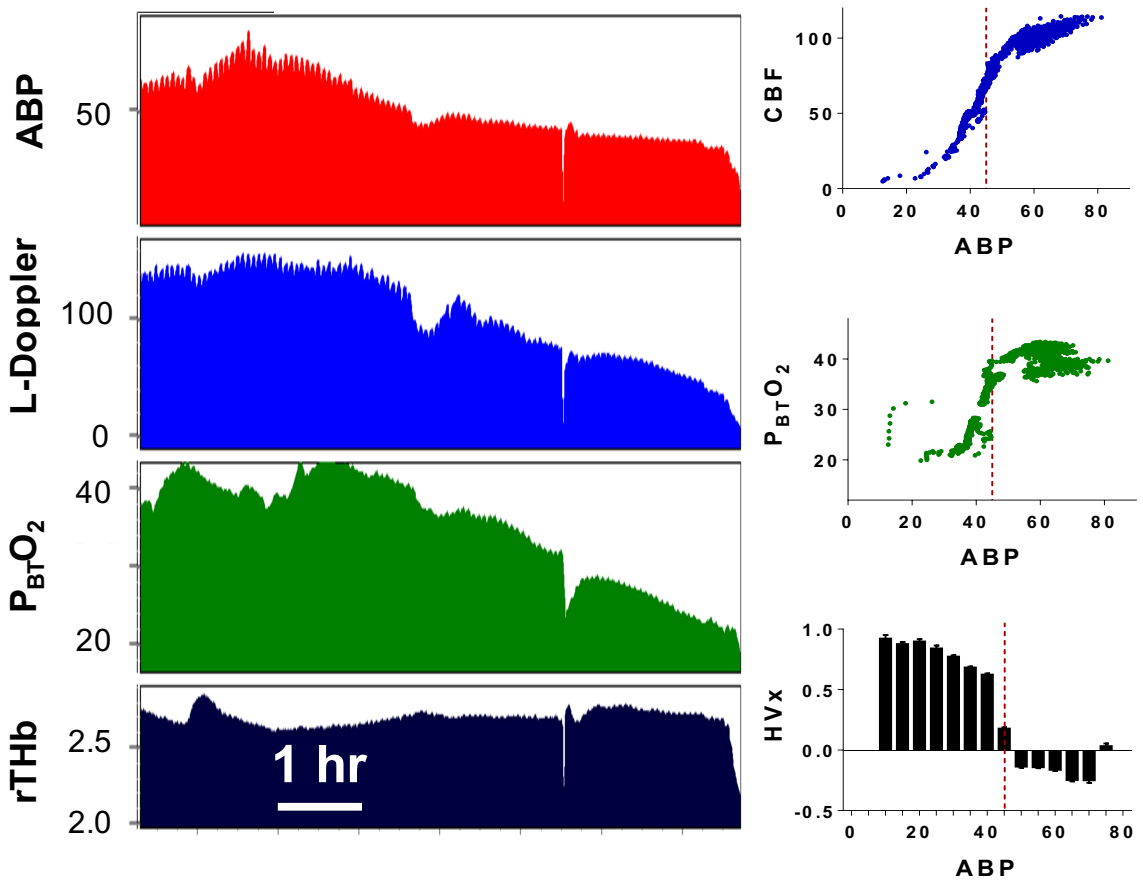


- Czosnyka M, *Stroke*, 1996
- Steiner LA, *Crit Care Med*, 2002

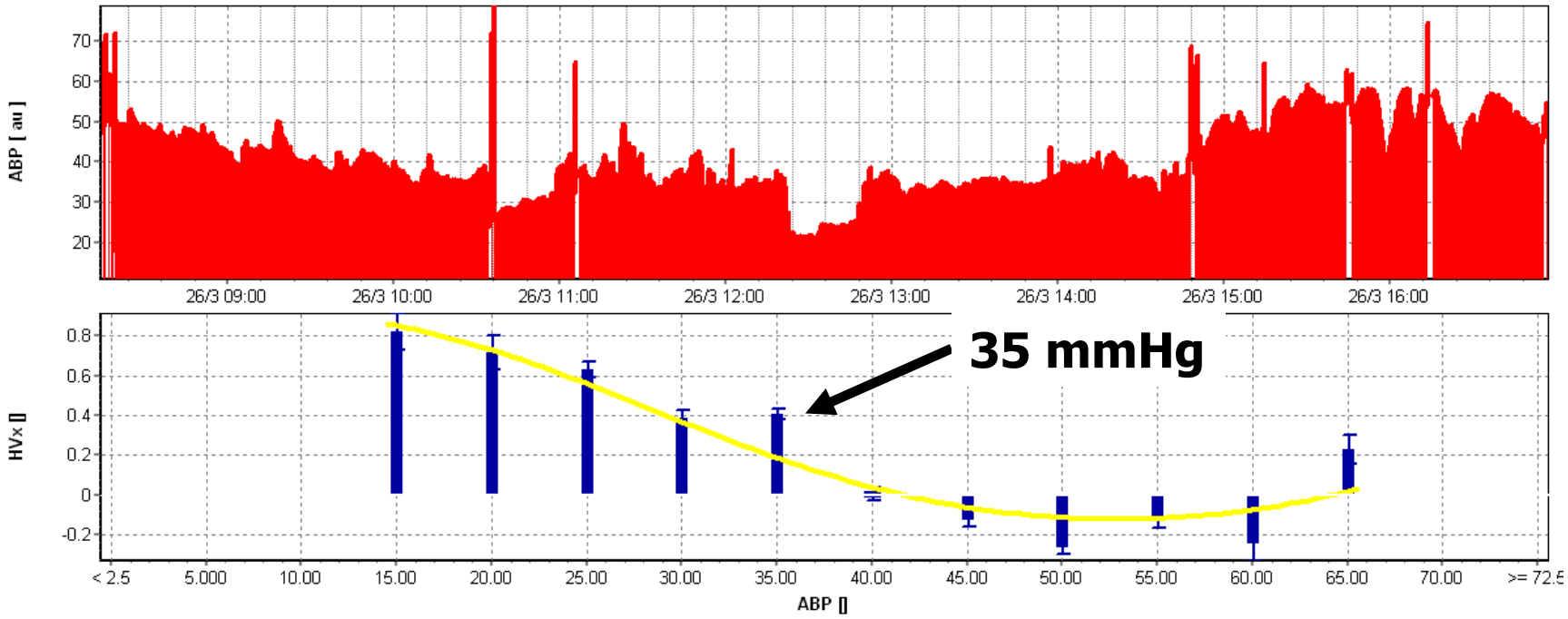
The Cambridge Method



Autoregulation monitoring during piglet bypass



What it looks like in a neonate on bypass



- ABP < 35 mmHg is associated with impaired autoregulation in this neonate
- ABP > 40 mmHg is associated with intact autoregulation in this neonate

JAMA Network™

From: **Effect of Targeting Mean Arterial Pressure During Cardiopulmonary Bypass by Monitoring Cerebral Autoregulation on Postsurgical Delirium Among Older Patients: A Nested Randomized Clinical Trial**

JAMA Surg. 2019;154(9):819-826. doi:10.1001/jamasurg.2019.1163

Table 2. Characteristics of Management During Cardiopulmonary Bypass for Patients Randomized to Standard Care vs Autoregulation-Targeted Management of Mean Arterial Pressure

Characteristic of Management	Standard Care (n = 94)	Autoregulation-Targeted (n = 105)	*P* Value
Phenylephrine, median (IQR), mg	1.2 (0.3-2.3)	1.8 (0.5-3.6)	.02
Vasopressin administration, No. (%)	6 (6.4)	9 (8.6)	.56
Cardiopulmonary bypass flow, mean (SD), L/min	4.4 (0.6)	4.4 (0.6)	.92
Isoflurane, mean (SD), %	0.76 (0.27)	0.77 (0.31)	.71
Arterial pressure during cardiopulmonary bypass, mean (SD), mm Hg	71.3 (7.6)	73.9 (6.7)	.01
Arterial pressure at the lower limit of autoregulation, mean (SD), mm Hg	68.7 (11.3)	66.0 (10.9)	.10
Product of the duration of time and mean arterial pressure below the lower limit of autoregulation, median (IQR), mm Hg × h[a]	9.5 (3.7-19.5)	5.3 (2.0-13.4)	.002

Abbreviation: IQR, interquartile range.

[a] Calculated as the product of duration of time and magnitude of bood pressure that mean arterial pressure was below the lower limit of autoregulation.

From: **Effect of Targeting Mean Arterial Pressure During Cardiopulmonary Bypass by Monitoring Cerebral Autoregulation on Postsurgical Delirium Among Older Patients: A Nested Randomized Clinical Trial**

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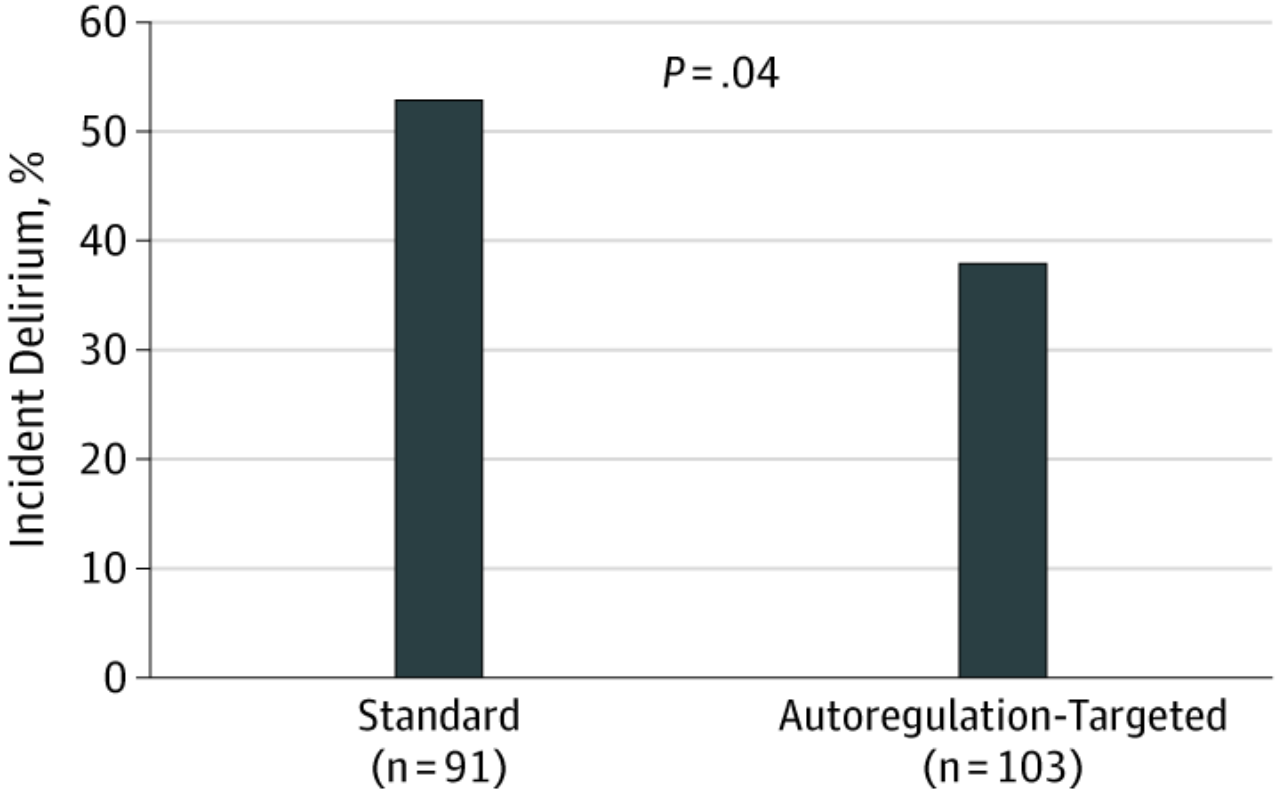
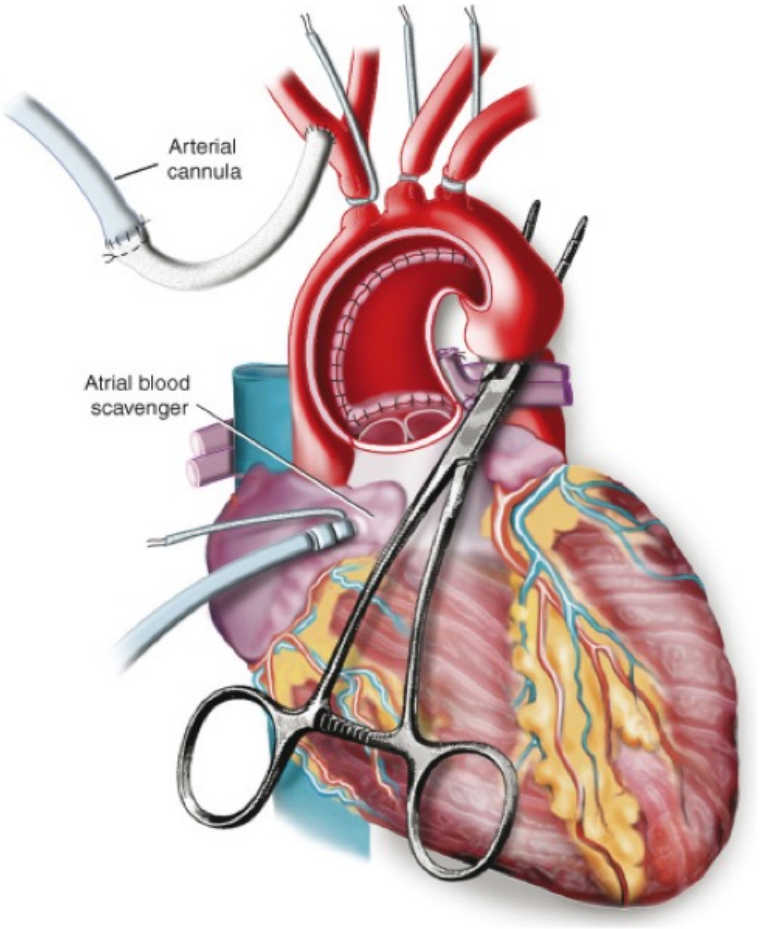


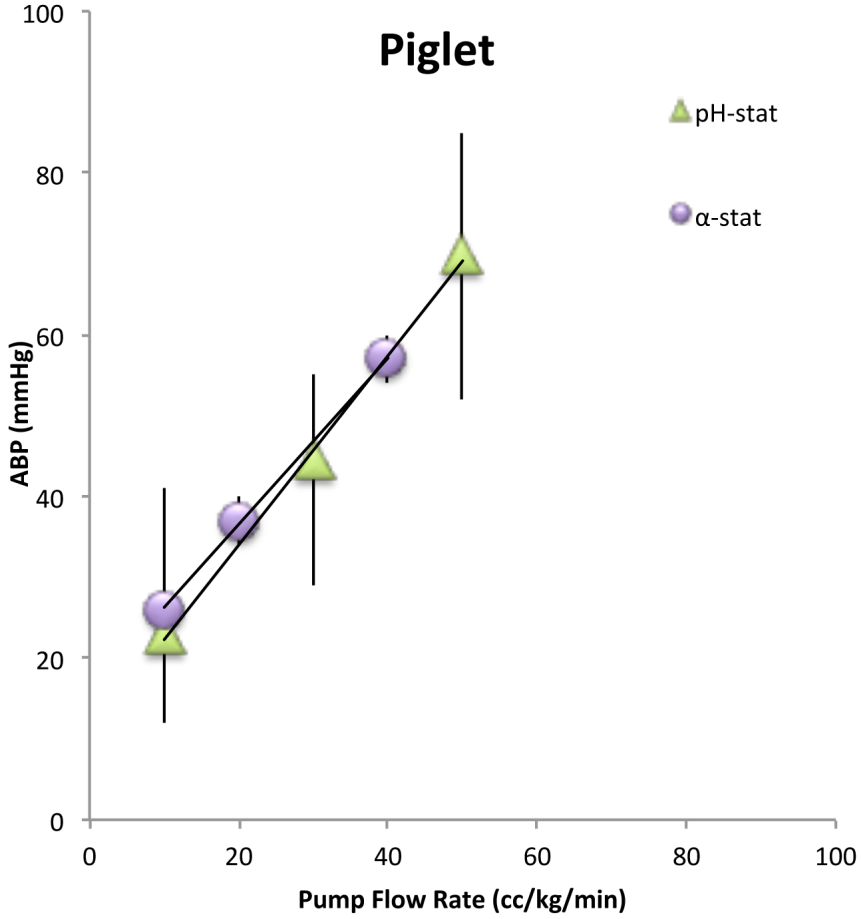
III. What about selective perfusion?

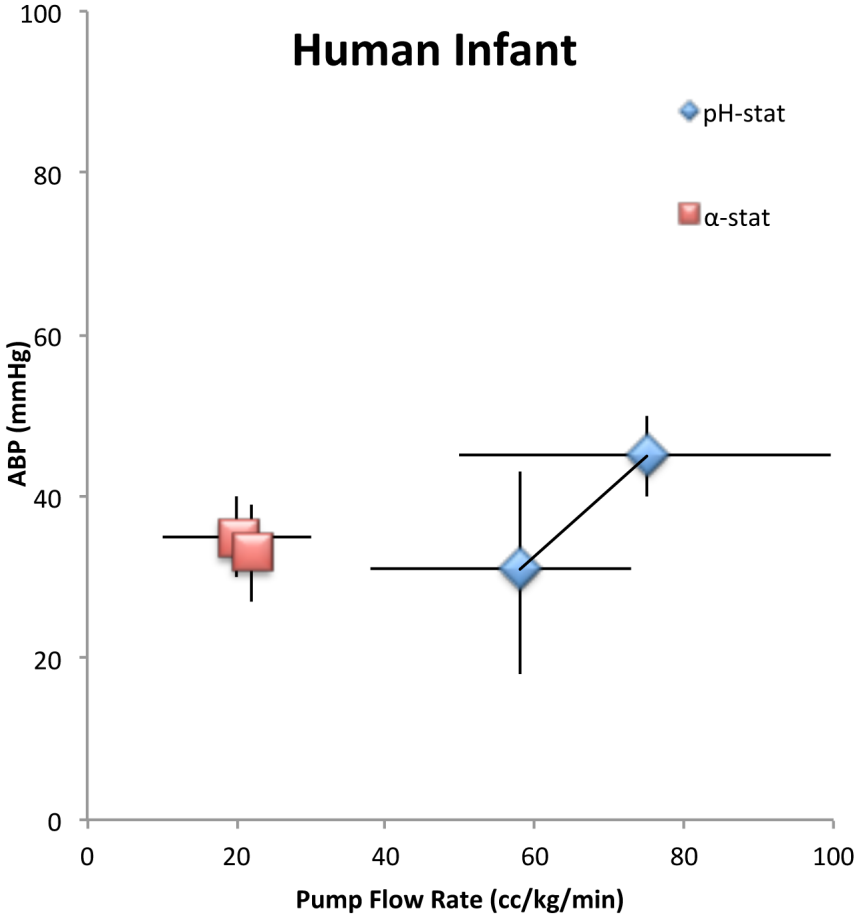
Issues with selective perfusion



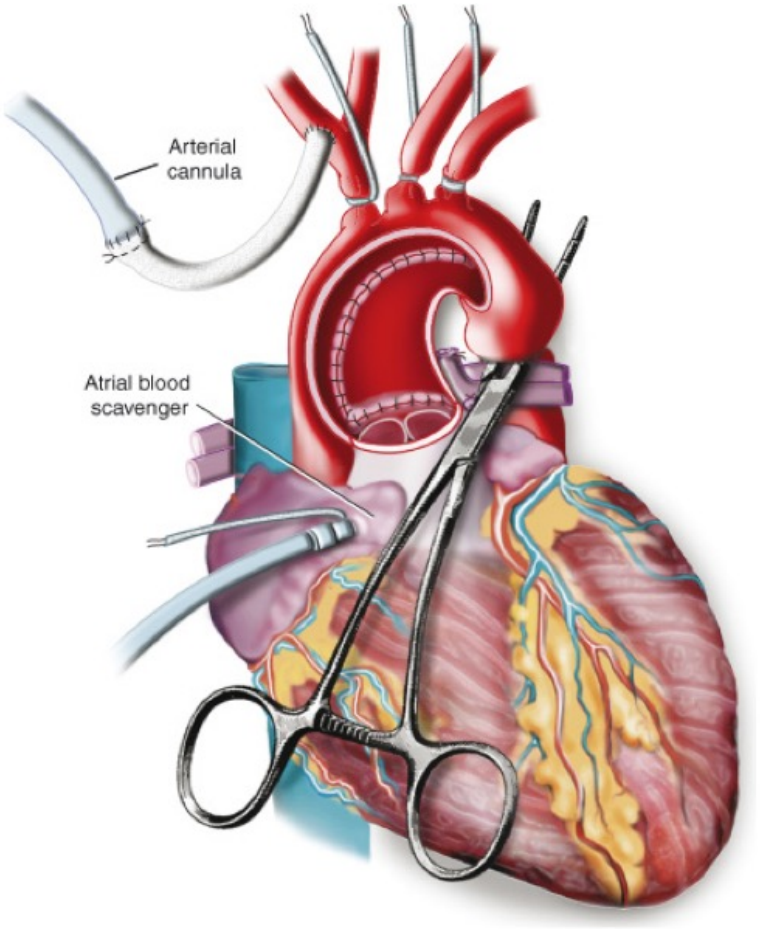
- Conflicting and limited outcome data
- Best method to cannulate?
- Flow rate?
- Monitoring?

SACP: How much flow?





The TCH method



- Graft to innominate artery
- Bilateral NIRS (circle of Willis check)
- TCD across the Fontanelle
- Baseline MCA flow velocity on full bypass at 18 degrees C
- DHCA for atrial septectomy
- Great vessels snared to start ACP
- Flow titrated to achieve baseline MCA flow velocity

What did we learn?

Conclusions

- The brain requires arterial blood pressure to autoregulate, regardless of the adequacy of cardiac output.
- The neonatal lower limit of autoregulation is usually between 35 and 45 mmHg.
- It is unclear if the brain can autoregulate during selective perfusion. Monitoring options include ABP and TCD.

Ann & Robert H. Lurie Children's Hospital of Chicago

Phase II study of autoregulation monitoring for neonatal cardiac surgery

- Dan Licht, Brad Marino, Ashok Panigrahy, Ken Brady
- **Feasibility:** can we change the dose of hypotension by knowing LLA?
- **Safety:** is it safe to use an ABP target above LLA?
- **Efficacy:** procure data to determine sample size needed.

Northwestern Medicine
Feinberg School of Medicine

Thank You

Blaine Easley
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Charles Hogue
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Peter Smielewski
Ray Koehler
Dean Andropoulos