The Value of NIRS and potential applications in V-A ECMO Patients

Luke Harris

MSc CPC LCP

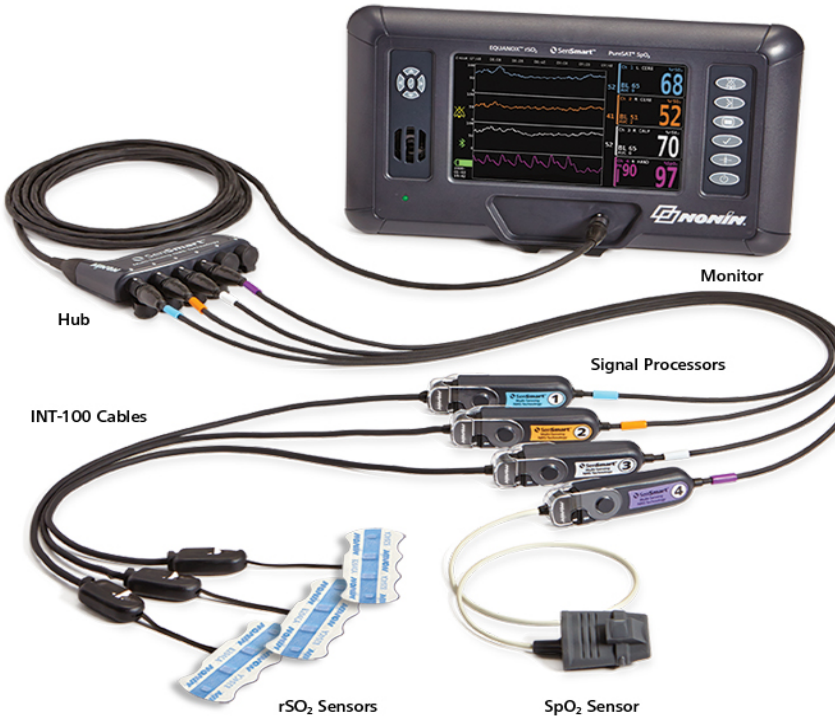
Dislcosure

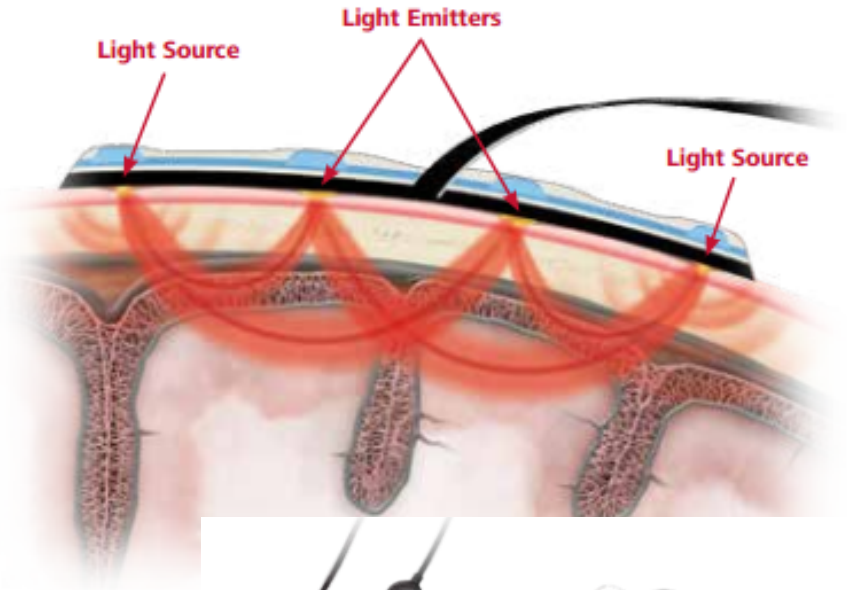
- Research equipment and disposables provided by **Nonin medical**

Objectives

- What is a regional Oximetry device?
- Noritoshi *et al* (2014) Study
- SPH ECPR oximetry study
- Assessment of Cerebral autoregulation and post arrest ECMO management

Near Infrared Spectroscopy (NIRS)





Nonin Sensmart

- NIRS measures:
  - Oxygenated Hb
  - Deoxygenated Hb
  - Total tissue hemoglobin (Hb) density
- Cerebral oximetry = oxygenated Hb/ total Hb
- Provides an Absolute value

SPH ECPR Program

- Specifically for out of hospital cardiac arrests
- The first formal ECPR program in Canada with prehospital-hospital integration

- Patients arrive with the LUCAS mechanical CPR device
  - Difficult to assess efficacy of CPR for this demographic

Can Cerebral Oximetry be used to assess efficacy of conventional CPR?

Use of NIRS in ECPR

Noninvasive regional cerebral oxygen saturation for neurological prognostication of patients with out-of-hospital cardiac arrest: A prospective multicenter observational study☆,☆☆

- Noritoshi *et al* 2014

Noritoshi *et al* 2014

- Japan based multicenter Study
- n= 672
- EMS providers not permitted to stop CPR in the field
- All out of hospital Cardiac arrests are treated at hospitals with an ED
- Used the INVOS oximeter device

Noritoshi *et al* 2014

- Can Cerebral Oximetry values provide:
  - A reliable means to predict likelihood of good neurological outcome?

- What Oximetry values are reflective of adequate perfusion during conventional (LUCAS) CPR?

Noritoshi *et al* 2014

- All cardiac arrest patients on arrival to the ED received rSO_2 monitoring within 3 minutes
- Monitoring commenced for 1 min
- Lowest rSO_2 reading was recorded
- Irrespective of rSO_2 values all patients received best therapy (ROSC or ECMO)
- Patients were categorized according to the Cerebral performance category (CPC) after 90 days

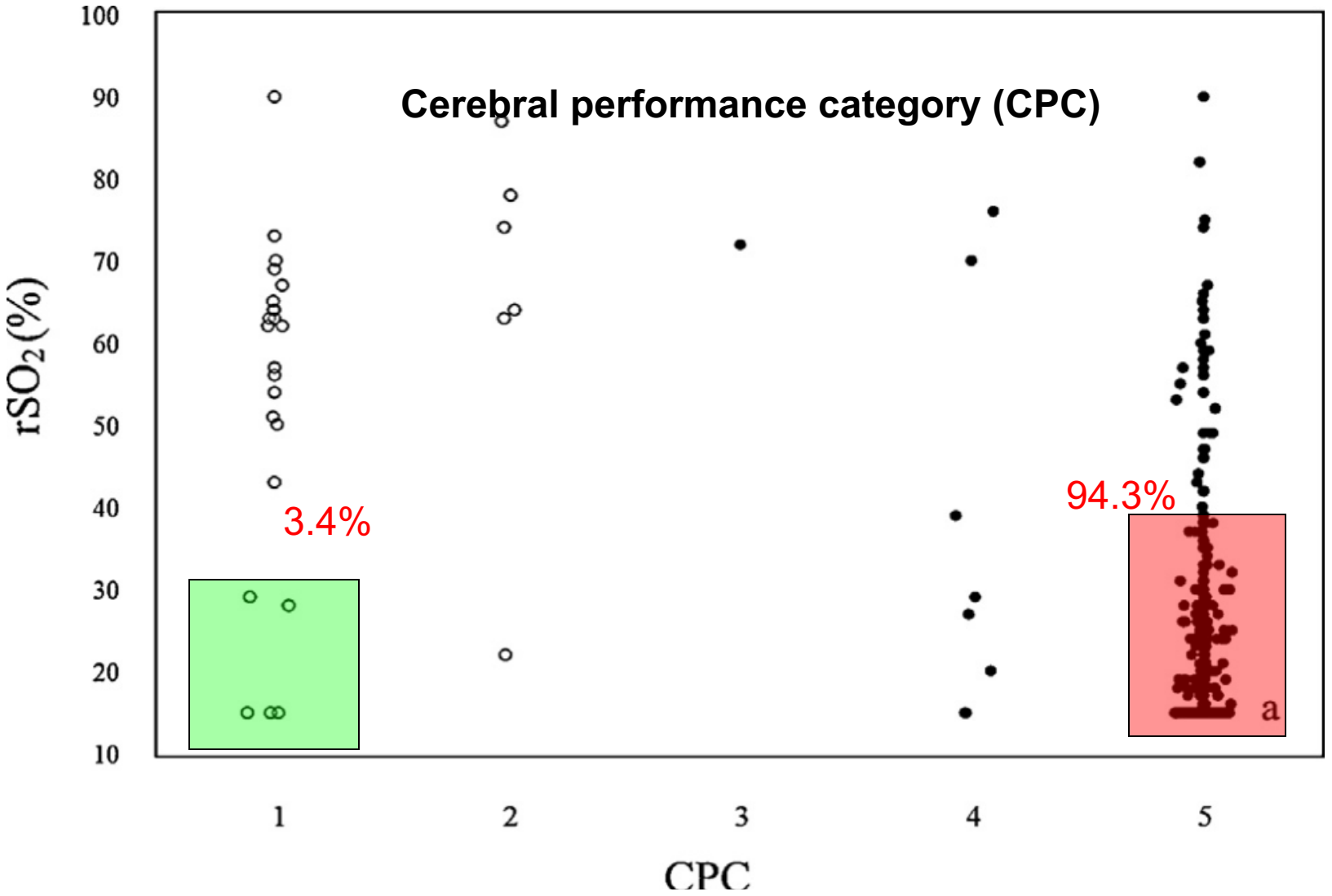
Cerebral Performance Categories Scale

CPC Scale

Note: If patient is anesthetized, paralyzed, or intubated, use "as is" clinical condition to calculate scores.
CPC 1. Good cerebral performance: conscious, alert, able to work, might have mild neurologic or psychologic deficit.
CPC 2. Moderate cerebral disability: conscious, sufficient cerebral function for independent activities of daily life. Able to work in sheltered environment.
CPC 3. Severe cerebral disability: conscious, dependent on others for daily support because of impaired brain function. Ranges from ambulatory state to severe dementia or paralysis.
CPC 4. Coma or vegetative state: any degree of coma without the presence of all brain death criteria. Unawareness, even if appears awake (vegetative state) without interaction with environment; may have spontaneous eye opening and sleep/awake cycles. Cerebral unresponsiveness.
CPC 5. Brain death: apnea, areflexia, EEG silence, etc.

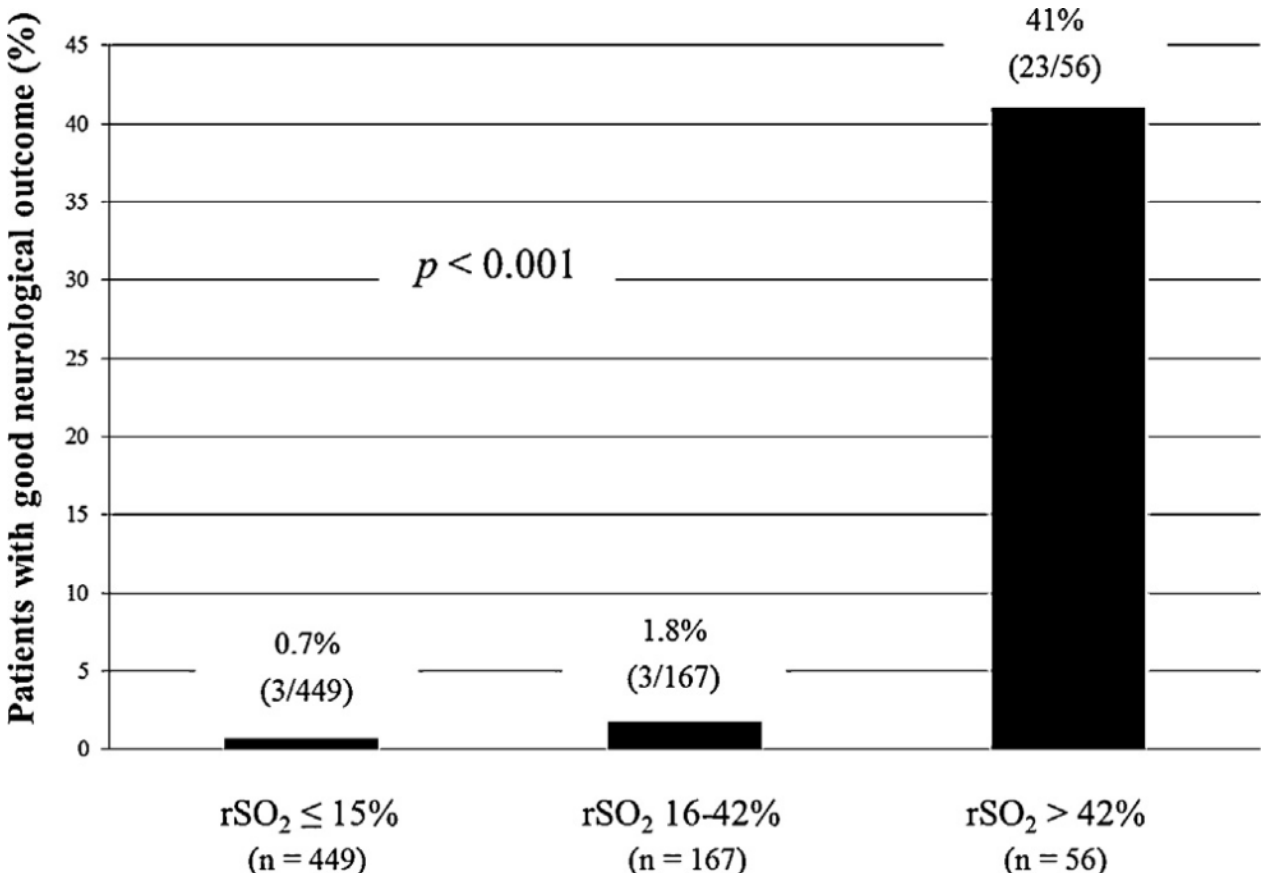
Safar P. Resuscitation after Brain Ischemia, in Grenvik A and Safar P Eds: Brain Failure and Resuscitation, Churchill Livingstone, New York, 1981; 155-184.

Results



N=672

Results



Cerebral performance category (CPC) 1

Results

- rSO_2 value of >42% optimal value for predicting good neurological outcome after OHCA at 90 days
- Even with ROSC and detectable pulses:
  - very low chance (1%) of obtaining good neurological out-come unless rSO_2 >42% at hospital arrival

Study findings

- Data strongly implies the probability of good neurological outcomes with an rSO_2 <42% is 0.97% p=0.001

Limitations

- Neurological outcomes were not correlated with age/ length of CPR and ECMO vs. non ECMO
- Length of time monitoring rSO_2 was limited
- rSO_2measured by NIRS reflects only cerebral perfusion at the superficial layers in the limited frontal lobe areas
- Reliability/consistency of Oximetry device

rSO_2 As a means to assess ECPR candidacy

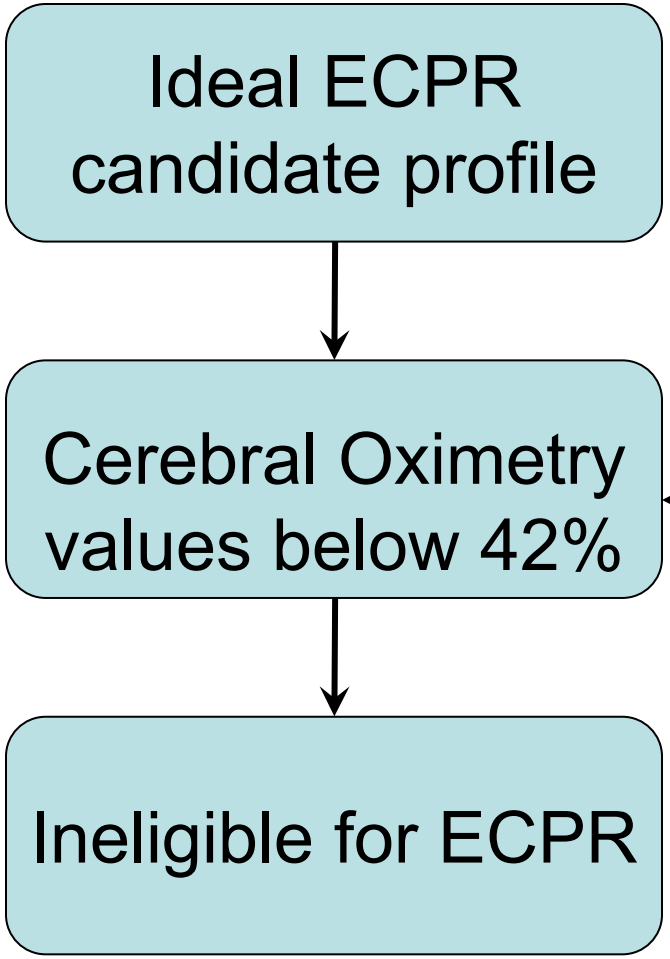
- SPH ECPR study:
  - Can we replicate the findings of Noritoshi *et al* 2014?
  - How can we improve the methodology?
  - Were Noritoshi *et al* right to focus solely on Oximetry values???

SPH current inclusion criteria **without** rSO_2

- Presumed Cardiac Etiology
- Age<65 yrs
- Witnessed arrest
- Bystander CPR
- Or Hypothermia

} Ideal Candidate!

Potential ECPR inclusion criteria with rSO_2



Could this scenario become a reality at SPH?

Poor CPR/Peripheral vascular disease/ dissection?

At SPH we will place **all** ECPR candidates on ECMO despite the rSO_2 value

ECPR Candidacy Dilemma

- Noritoshi *et al* (2014) acknowledge:
  - A small percentage (1%) of patients with an rSO_2 below 42% achieved good neurological outcome (CPC 1)
  - Adherence to a strict ECPR protocol becomes a moral and ethical dilemma for “ideal candidates” if using rSO_2 as a secondary means to assess candidacy for ECPR

SPH study

- Improve upon the Noritoshi study
  - Very specific patient population (ECPR ECMO patients only)
  - Correlate length of CPR-ECMO with neurological outcome

- Ultimate goal: Reliably predict good neurological outcome with 100% accuracy for ECPR candidates (Realistic??)

- Unlike the Noritoshi study:
  - Nonin device provides Absolute values as opposed to the INVOS which only provides a Trending Value = greater reliability

SPH Oximetry study

- What is Cerebral oximetry monitoring telling us about the Patient?
  - Could this improve/ direct post Cardiac arrest care?

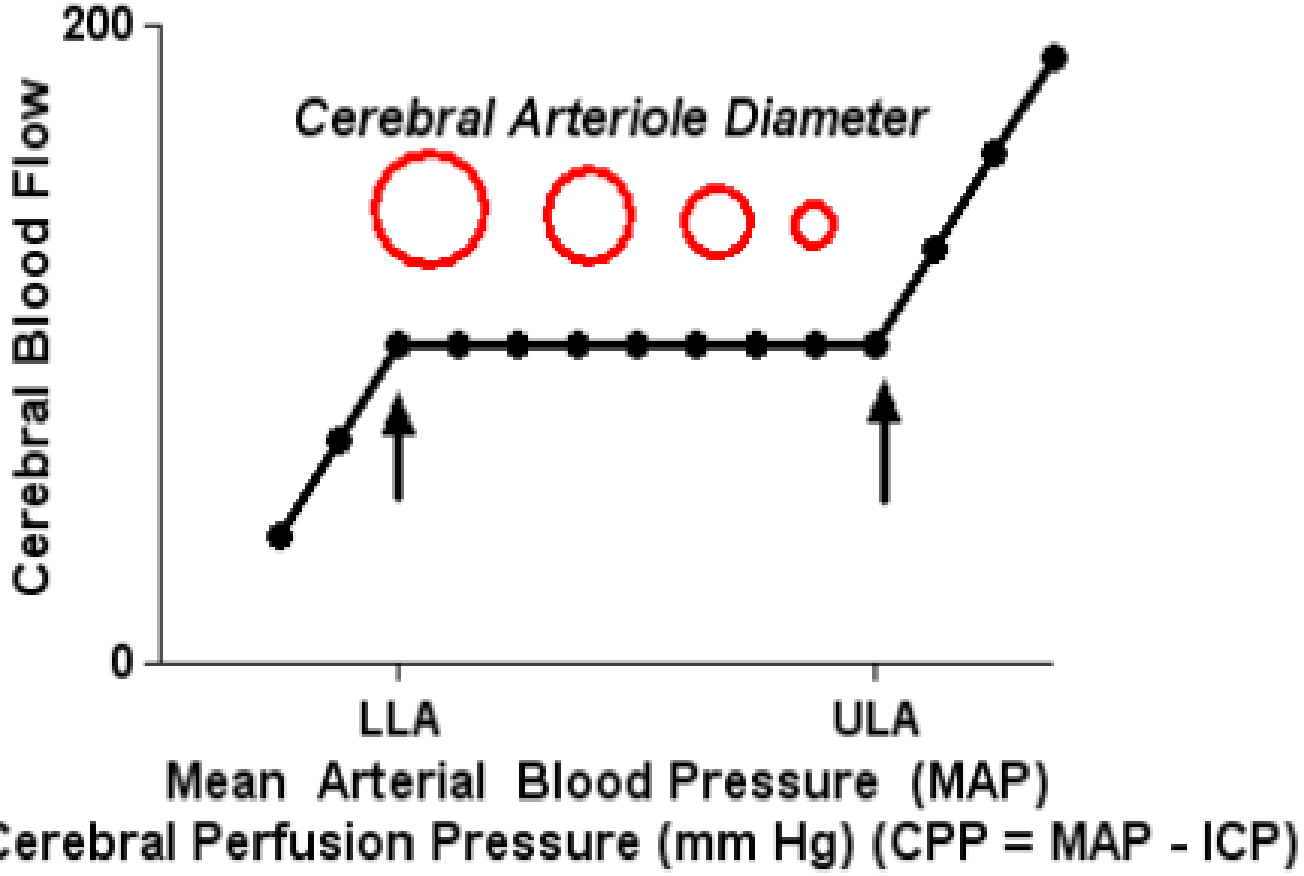
- Can we use Cerebral oximetry and MAP to determine integrity of Cerebral autoregulation?

Assessment of Cerebral Autoregulation

- Loss of Cerebral autoregulation is "*strongly associated with poor neurological outcomes*"

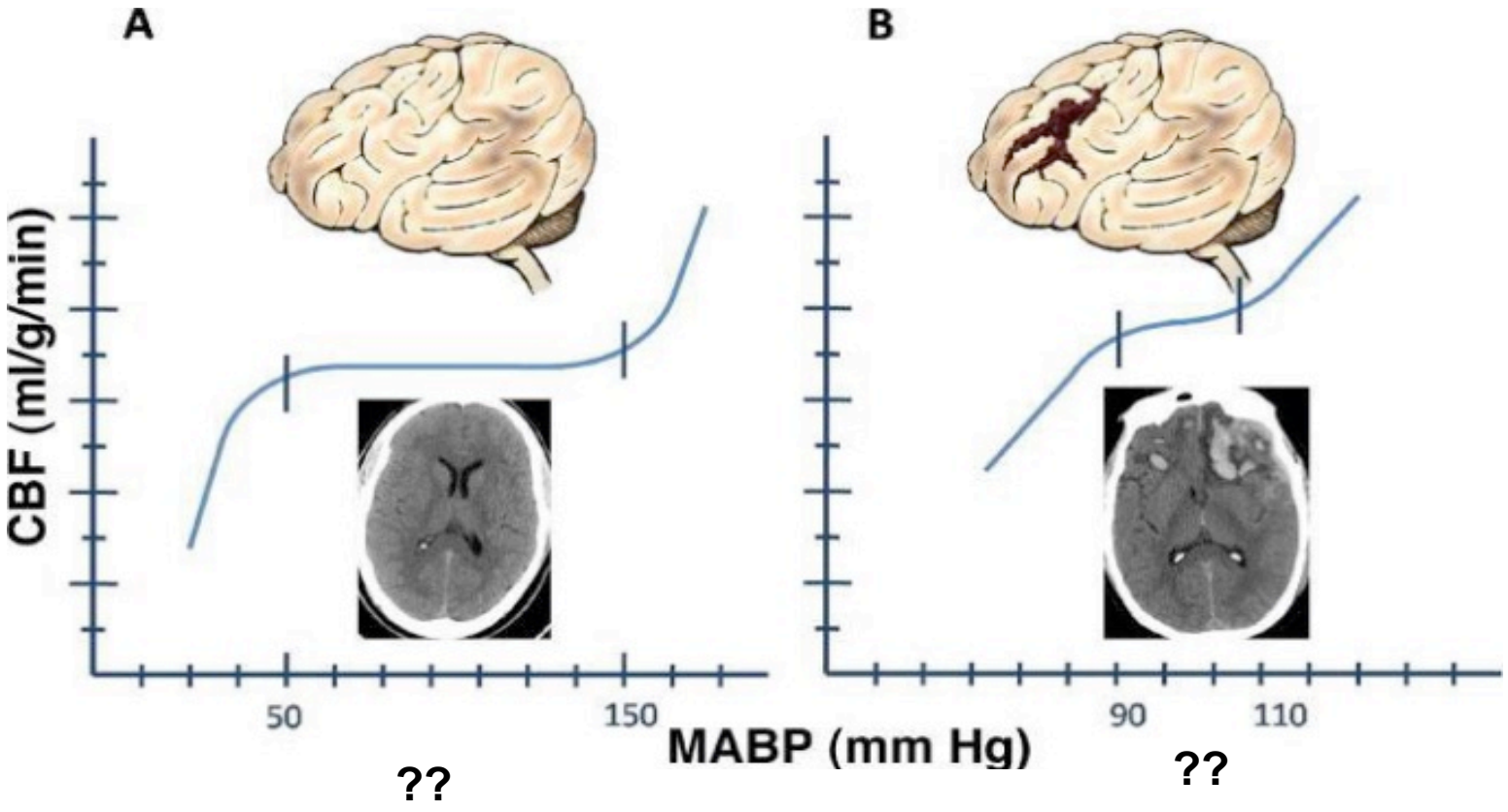
Rangel-Castilla *et al, Neurosurgical Focus* 2008

Lower and Upper limits of Cerebral autoregulation



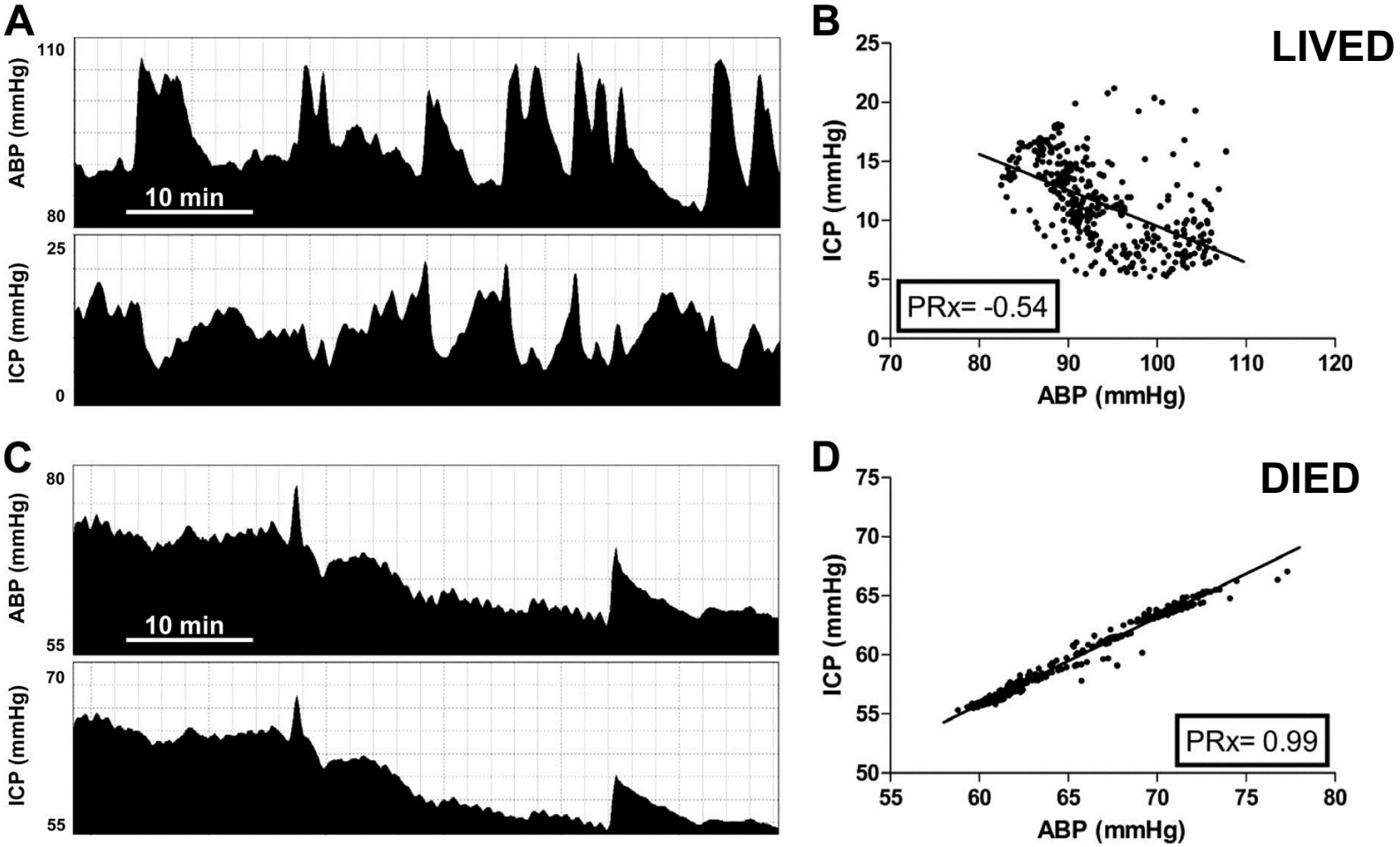
LLA = Lower limit of auto-regulation ULA = Upper limit of autoregulation

Does ability to preserve Cerebral autoregulation determine survivability?



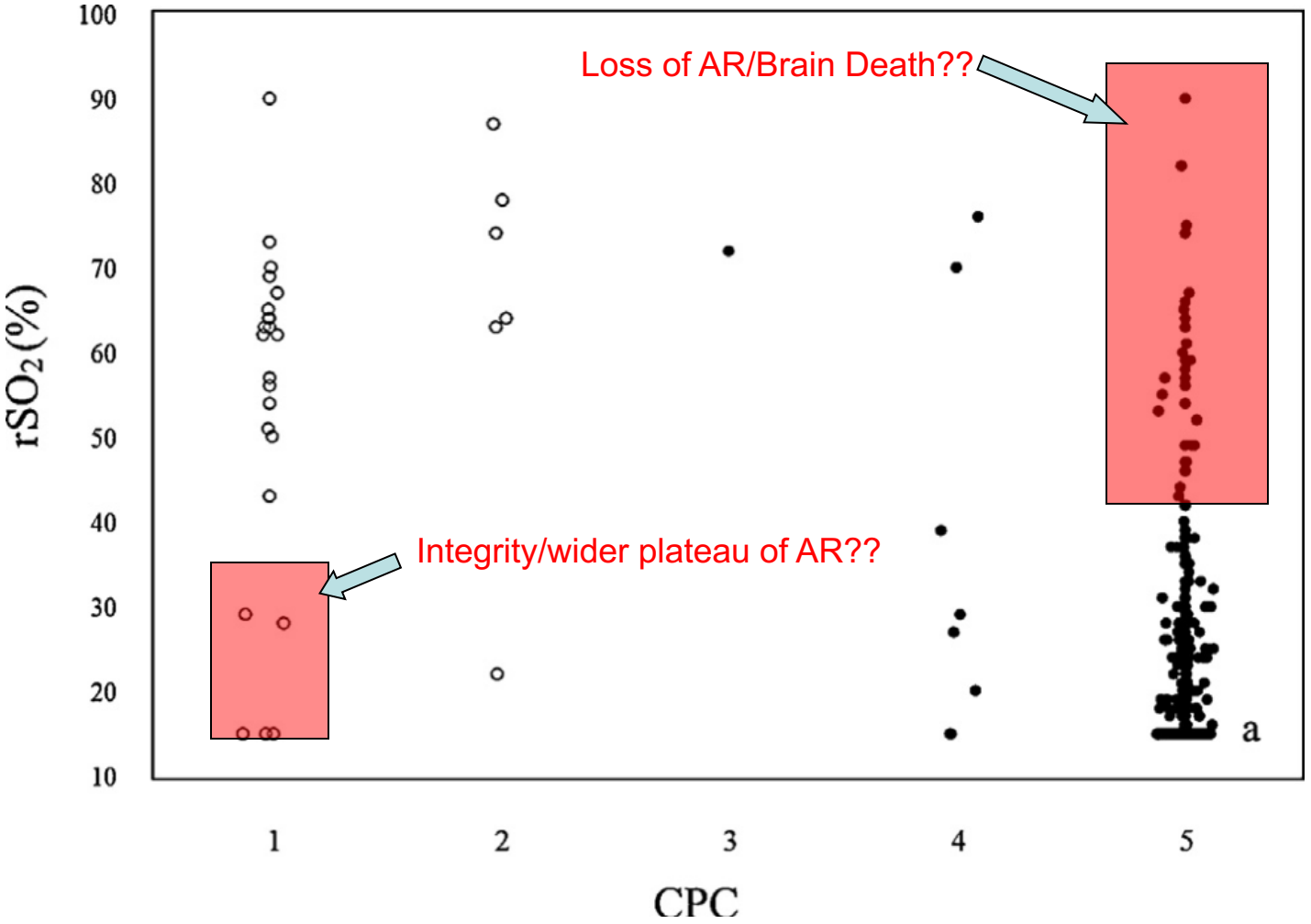
Rangel-Castilla *et al, Neurosurgical Focus* 2008

Autoregulation Index: ICP and Cerebral Blood Volume



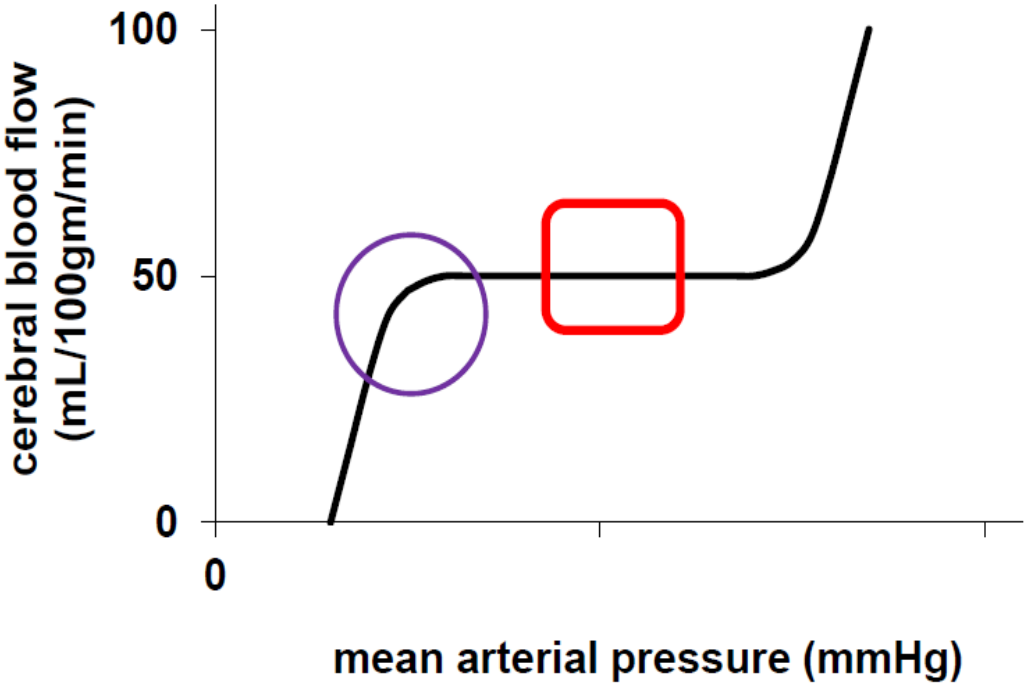
Brady KM, et al. *Pediatrics.* 2009

Autoregulation



Cerebral Performance Category

Goal: To develop an autoregulation monitor that tells us *where* the patient is on the curve as blood pressure changes…



Should we target blood pressures that optimize autoregulation?

NIRS and Cerebral autoregulation

- "*Non-invasive near-infrared spectroscopy accurately identified the lower limit of autoregulation during normothermia and hypothermia in piglets resuscitated from arrest*"

Lee *et al* 2011

Cerebral oximetry to assess autoregulation functionality

- Δtissue O_2 saturation is proportional to Δcerebral blood flow with stable metabolic rate and oxygen supply
- Lose autoregulation: cerebral oximetry becomes passive to arterial blood pressure (ABP)
- How could this direct care in the ED and CSICU for ECPR patients?

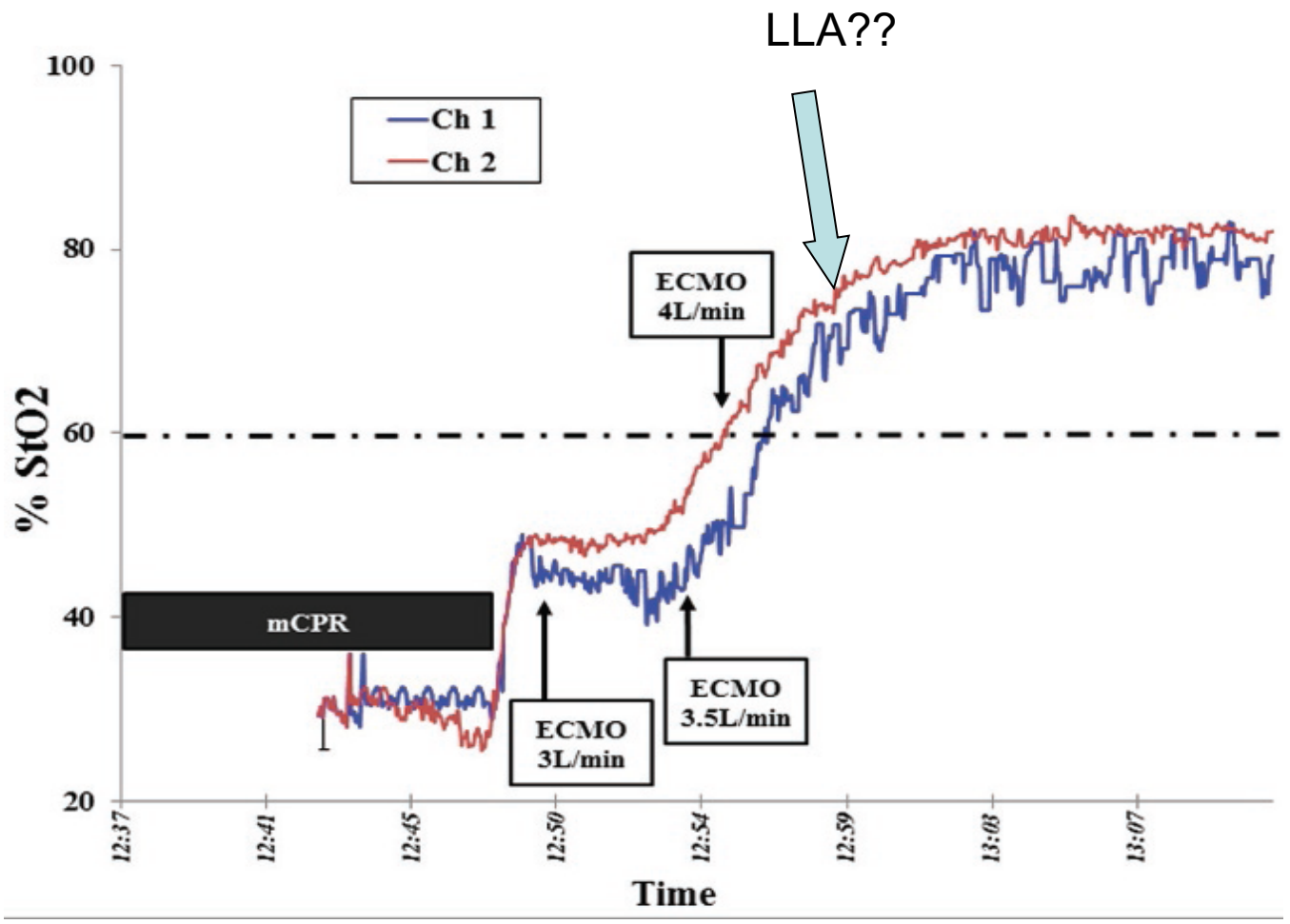
Lee *et al* 2016

Can Cerebral Autoregulation be assessed using NIRS on ECMO patients?

- "*Manipulations of ECMO flows are associated with regional changes in cerebral autoregulation which may potentially have an important bearing on clinical outcome*"

Papademetriou *et al* 2013

Taccone *et al* 2013



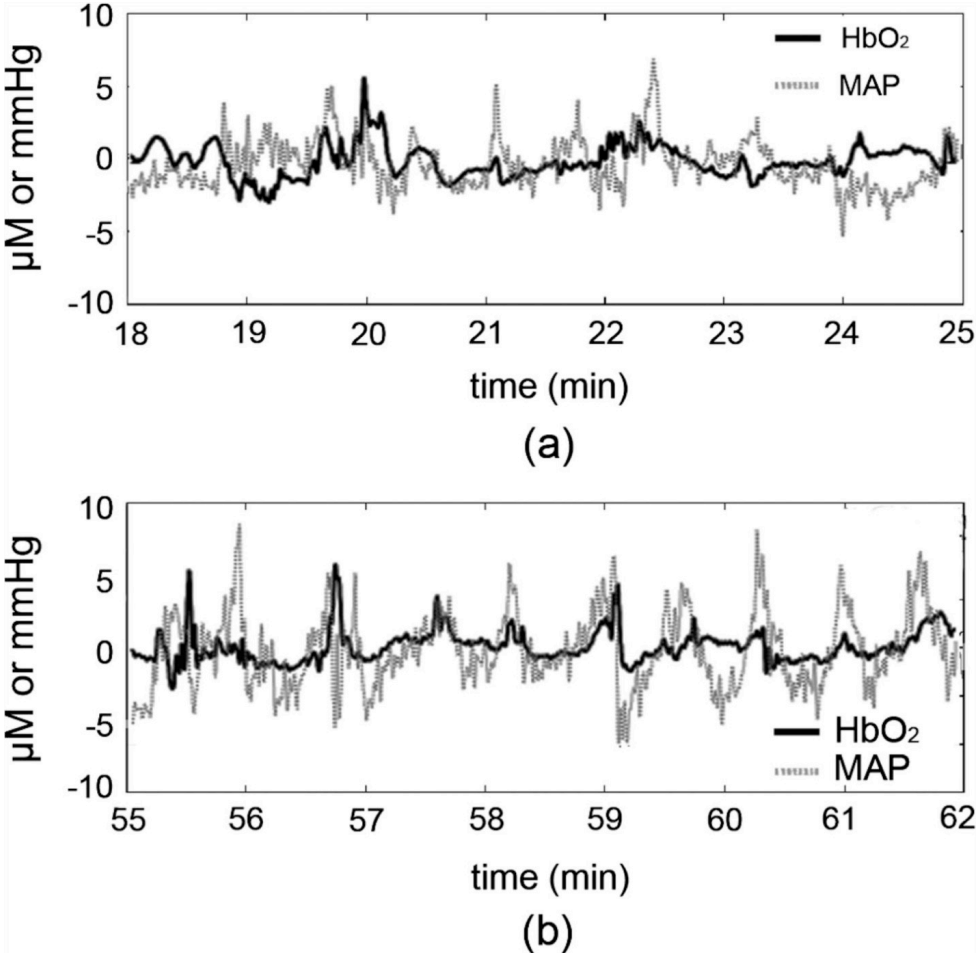
MAP at 3l/min flow = 67 mm Hg
MAP AT 4L/min = 83mmHg

Cerebral Blood flow is **passive** to MAP and Cardiac output

Taccone *et al* 2013

- "*It remains unclear how systemic hemodynamics should be adjusted to ensure adequate cerebral oxygenation*"

V-A ECMO



100% ECMO flow
Overall functional autoregulation

70% ECMO flow
Pressure passive

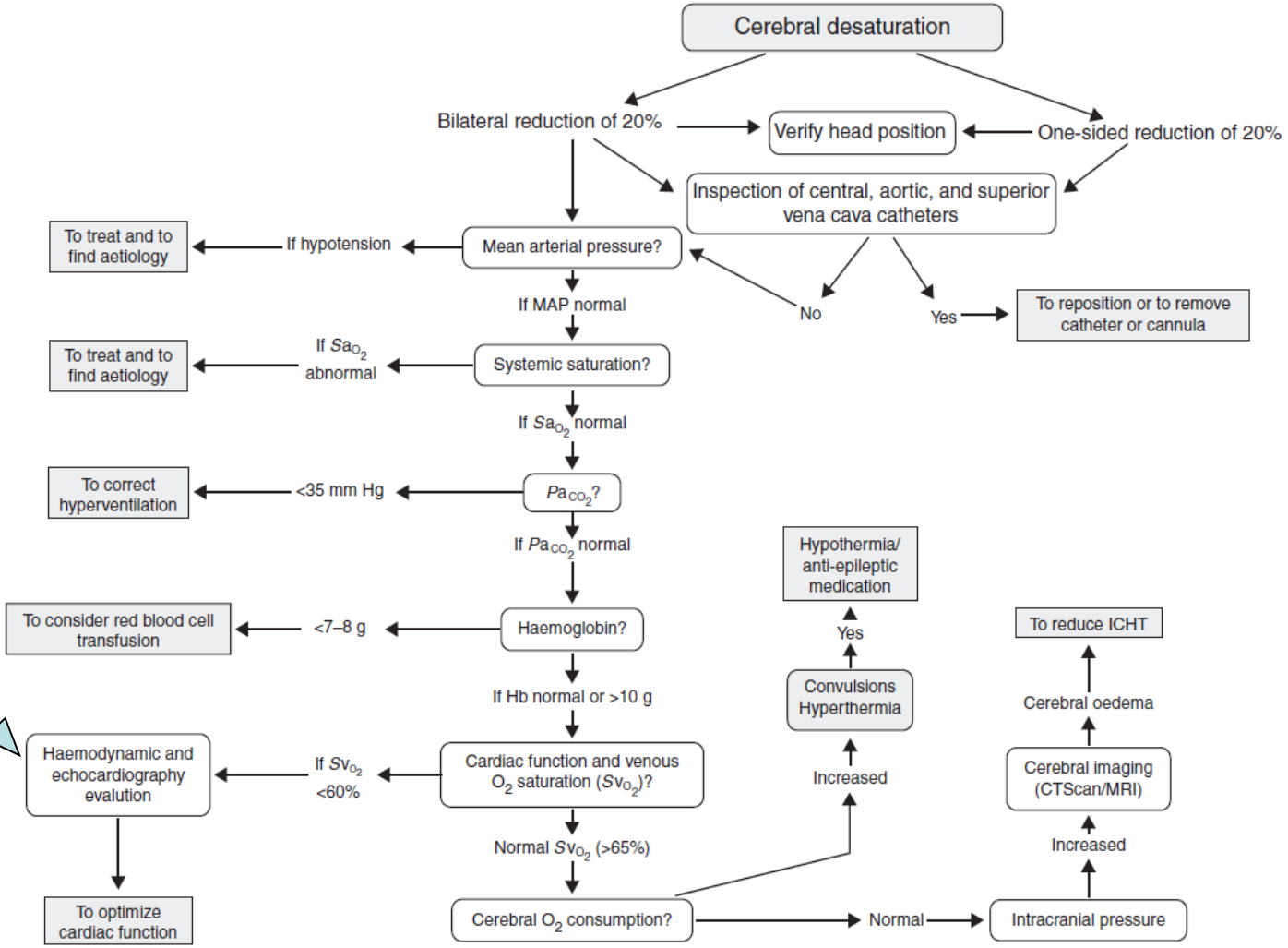
Papademetriou MD, et al. *J Biomed Opt* 2015

Clinical management of V-A ECMO flows

- By trending both MAP/ECMO flows and Cerebral Oximetry one can discern the lower and upper limit of autoregulation

- When cerebral oximetry becomes passive to variations in ECMO flows and MAP this suggests inadequate cardiac output and MAP to maintain cerebral autoregulation

NIRS based care model



Optimize ECMO flows

Murkin & Arango 2009

Conclusions

- Can we use rSO_2 as a definitive means to assess candidacy for ECPR and good neurological outcomes?
- Can we use rSO_2 to improve resuscitation attempts and post arrest care?
- Does ECPR offer a greater chance of post arrest survival?

Questions/Comments