Detecting Cerebral Autoregulation Thresholds Using a Noninvasive Cerebral Flow Monitor

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Introduction

Cerebral autoregulation (CA) refers to brain's vasculature ability to maintain adequate blood flow in face of changing blood pressure both high and low. CA has long been known to be a vital component in brain function, and has been recently shown to be a measure of hemodynamic integrity with impact on morbidity and mortality both during surgery and in disease states[1,2].

Various cerebral injuries, systemic pathologies influencing cerebral vasorectivity (e.g. chronic hypertension, diabetes mellitus etc.) and drugs, may suppress the AR response or shift its upper or lower limits[3,4] (LLA). Thus the ability to monitor CBF changes and the limits of AR are of great importance in the management of patients where cerebral perfusion may be compromised.

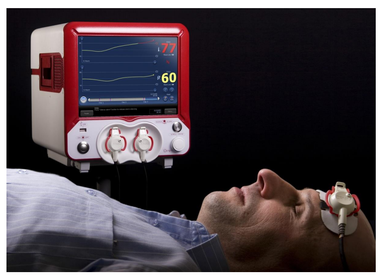
In the present study we examined a new non-invasive hybrid technology employing ultrasound tagged near infrared spectroscopy (UT-NIRS), which has been shown to monitor CBF[5].

The goal of this study is to assess the ability of the CerOx monitor to define the zone of AR and its limits in an animal model, during stepwise changes of blood pressure using vasoactive drugs.

Methods

Newborn piglets were anesthetized using Ketamine, Propofol and Fentanyl. Heart rate and Blood Pressure (MAP) were monitored continuously using an arterial line. Cerebral Blood Flow (CBF) was monitored using the Cerox monitor (Ornim, Israel). Blood flow was manipulated using continuous infusion of Phenylephrine or Nitroprusside to reach MAP values between 40-180mmHg for individual animals, to detect AR and its upper and lower limits.

A moving correlation coefficient *(CF_x)* was calculated between CFI (Cerebral flow index by CerOx) and MAP. CF_x values were categorized in 10 mm Hg bins of MAP for each experiment. ***The CF_x value indicating autoregulation is not known, but based on prior work[1], was chosen at 0.4***.



Results

Five animals (age 4 weeks, average weight 18 kg) were tested (total: 6 experiments). MAP was lowered to 40 mmHg and raised to 180 mmHg using stepwise increases of drug dose in 7-10 minute intervals.

CFI was plotted as a function of MAP and LLA was visually detected in 5 of 6 experiments median 99.2, ranging from 79 to 140mmgH (*table 1)*. In one experiment (#6), MAP did not drop below 90mHg, and LLA was not detected.

Experiment	LLA (mmHg)
1	92
2	95
3	140
4	79
5	90
6	Not detected
Mean	99.2

Table 1: Lower Limit of Autoregulation (LLA)

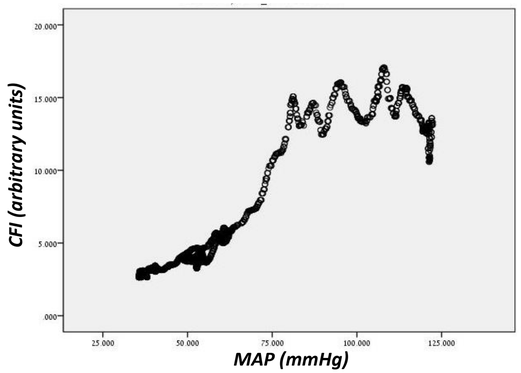


Figure 1: Cerebral Blood Flow vs. Blood Pressure (exp 4)

The CF_x value was calculated in each experiment separately. Figure 2 shows the CFX values for each animal, over the binned MAP values. For most experiments (but #3), autoregulation was observed above MAP of 100mmHg.

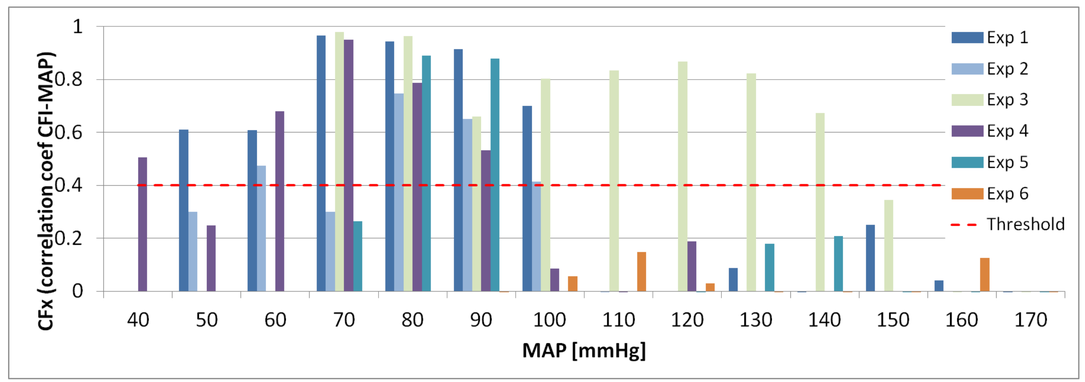


Figure 2: Moving correlation coefficient (CF_x) between CFI and MAP as a function of MAP. A decrease in CF_x is noted for MAP bins greater then 100.

Discussion

The study demonstrated the AR range and its lower limits. In 5 out of 6 experiments, we could easily identify the LLA. In all animals we were not able to raise BP significantly enough to identify the upper limit of AR.

Conclusions

- Limits of AR are variable amongst individual piglets under identical conditions.
- CBF and LLA can be detected continuously and noninvasively using UT-NIRS technology.

References:

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