Optical Neuromonitoring Guided Partial Aortic Occlusion During Prolonged Hypoxic Cardiac Arrest: A Large Animal Feasibility Study

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THE BOTTOM LINE

In a swine model of prolonged hypoxic cardiac arrest, dynamic fractional aortic occlusion titrated via non-invasive neurometabolic optical monitoring (NOM) was technically feasible, better preserved cerebral physiology, and showed a strong signal toward higher ROSC rates.

INTRODUCTION

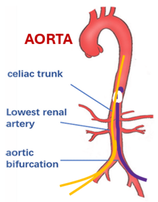
- **The Problem:** Outcomes for prolonged cardiac arrest in austere environments remain dismal without extracorporeal life support (ECLS).
- **The Drawback of Static AO:** Complete aortic occlusion (AO) boosts cerebral perfusion during CPR but carries severe risks of proximal hyperperfusion injury and distal ischemia.
- **The Proposed Solution:** Combine **fractional AO** with **real-time non-invasive Neurometabolic Optical Monitoring (NOM)** to dynamically titrate cerebral oxygenation/perfusion to individual physiological targets.
- **Study Objective:** Evaluate technical feasibility and characterize physiological/ROSC responses using NOM-guided dynamic AO.

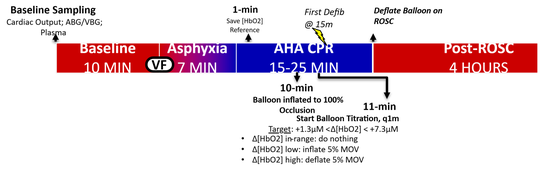
METHODS

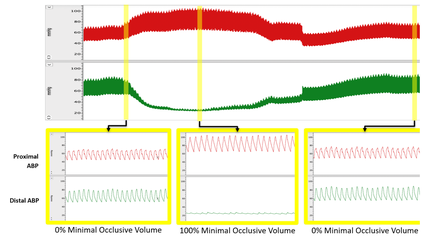
Experimental Protocol (Swine Model, n = 4)

- **Model:** 1-month-old swine (8-12 kg).
- **Insult:** 7 min asphyxia → electrically-induced VF cardiac arrest→ depth-directed CPR.
- **Intervention (CPR Min 10):** Inflation and real-time NOM-guided dynamic titration of Zone 1 aortic balloon to maintain target oxyhemoglobin ranges.
- **Defibrillation:** Initiated at 15 min of CPR.
- **Comparison Group:** Descriptive comparison against historical standard CPR controls (n = 16).

EXPERIMENTAL DESIGN







RESULTS

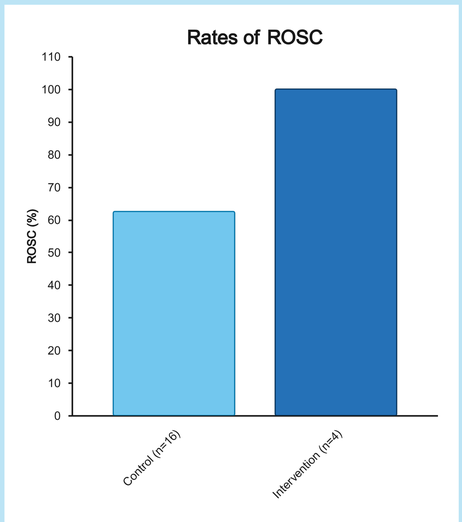


Figure 1. Rates of return of spontaneous circulation (ROSC), control vs intervention.

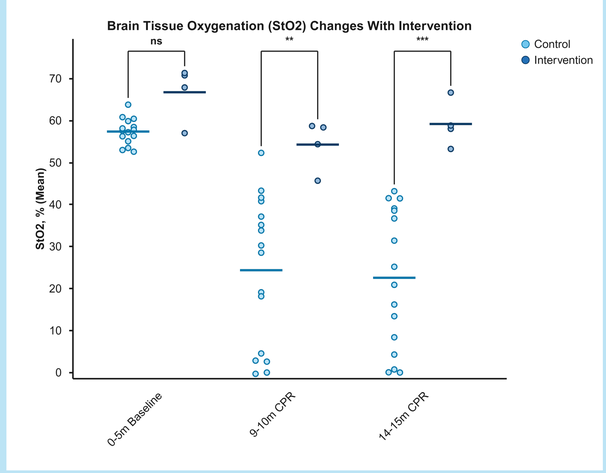


Figure 2. Effect of Intervention on Brain Tissue Oxygenation (StO2). Comparison of mean StO2 (% +/- SEM) between Control and Intervention groups across baseline (0-5min), CPR Pre-Intervention (9-10 min), and CPR Post-Intervention (14-15 min). Statistical significance determined via two-way mixed-effects model with Tukey's post-hoc test(**p < 0.01, ***p<0.001, ns=non-significant).

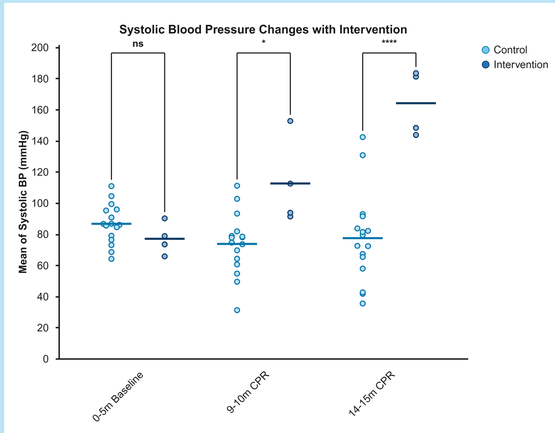


Figure 3. Effect of Intervention on Systolic BP. Comparison of mean SBP (mmHg) between Control and Intervention groups across baseline (0-5min), CPR Pre-Intervention (9-10 min), and CPR Post-Intervention (14-15 min). Statistical significance determined via two-way mixed-effects model with Tukey's post-hoc test (*p<0.05, ***p<0.001, ns=non-significant).

Feasibility & Safety Profile

- **Technical Success:** 100% (4/4) successful access, balloon placement, and dynamic optics-guided titration.
- **Safety Events and Complications:** Zero cases of aortic rupture or intracranial hemorrhage, however distal arterial thrombosis (n= 2/4) and right atrial injury from PAC did occur (n = 3, excluded from analysis cohort).

CONCLUSION

- **Proof of Concept**: Vascular access and placement of an endovascular balloon was efficient and technically feasible. NOM-guided fractional AO during prolonged arrest is achievable and limits severe cerebral hypoperfusion during CPR.
- **Resuscitation Signa**l: Demonstrated higher ROSC rates, blood pressure augmentation, and improved cerebral tissue oxygenation when compared to standard CPR.
- **Field Application**: Offers a promising endovascular platform for Prolonged Field Care (PFC) and delayed evacuation environments where ECLS is absent.

NEXT STEPS

- Perform larger, randomized study with concurrent control group.
- Assess longer-term survival and neurologic recovery with a survical cohort.
- Evaluate efficacy in additional physiologic models (Hemorrhagic Shock, Septic Shock, etc)
- Refine balloon volume titration mechanics with the ultimate goal of **closed-loop, autonomous, and personalized resuscitation.**

ACKNOWLEDGEMENTS

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