

Ocular Pressure Adjusting Pump with Positive Pressure (OPAP+) as a Countermeasure for Spaceflight Associated Neuro-ocular Syndrome (SANS): Strict Head-down Tilt Bed Rest (HDTBR) Pilot Study

#### 1. PRINCIPAL INVESTIGATOR

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#### 2. ESTIMATED DURATION OF THE STUDY

Estimated duration: 3 months

Start date: March 22th, 2026

3 week experimental window, 2 month data analysis

#### 3. SPECIFIC AIMS

Utilize 21-days of strict 6-degree HDTBR with one human volunteer in a contralateral-eye study design to determine the safety and efficacy of OPAP+ as a countermeasure (CM) for SANS-like optic disc edema (ODE) formation (**OCT Measure**)

#### 4. BACKGROUND AND SIGNIFICANCE

Spaceflight associated neuro-ocular syndrome (SANS) refers to a variety of symptoms and clinical findings commonly diagnosed in astronauts exposed to long duration spaceflight (LDSF). Clinical findings include optic disc edema with increase in peripapillary total retinal thickness (TRT), choroidal folds, cotton wool spots, translaminal pressure gradient (TLPG) distortions, globe flattening, visual acuity impairment, visual scotomas, and headache (see reference 1).

OPAP- was the first negative-pressure ophthalmodynamometer, enabling controlled, stepwise reductions in IOP while maintaining direct imaging of the optic nerve head through optically clear goggles. Unlike older ophthalmodynamometers, which could only increase IOP and necessitated physical deformation of the eye with locally applied pressure, OPAP's approach permits the first known noninvasive reduction in IOP (references 2-4 below). Conversely, the OPAP+ system provides positive pressure in a similar, non-invasive approach to reduce post-operative complications for glaucoma. With its utility in modulating IOP directly, the OPAP system was identified as a potential tool to directly intervene on TLPG changes and the resulting ocular deformities impacting astronaut vision while in flight.

This study aims to establish both safety and efficacy of OPAP+ use in a clinical context of increased IOP and ICP. Utilizing Strict Head-down Tilt Bed Rest (HDTBR, benchmark spaceflight analogue) at 6-degrees for 21 days, optic disc edema and ICP increases are expected to develop. OCT use will assist surveillance for safety concerns (retinal, subretinal pathology) and provide direct validation of OPAP+ efficacy to impact known pathophysiological variables in SANS including total retinal thickness (OCT measure) and resulting clinical changes.

#### 5. POTENTIAL BENEFITS

The shared purpose and benefit between all participants in this study continues to echo the words of President Kennedy, said at Rice University on 9/12/1962:

“There is no strife, no prejudice, no national conflict in outer space as yet. Its hazards are hostile to us all. Its conquest deserves the best of all mankind, and its opportunity for peaceful cooperation may never come again.”

As OPAP-based interventions become validated to provide direct control over IOP changes, both Space diseases like SANS and Terrestrial like IHH and Glaucoma will provide a treatment avenue to normalize the translaminal pressure differential in difficult to treat conditions.

#### 6. RESEARCH DESIGN AND METHODS

General summary: Utilize 21-days of strict 6° HDTBR with one human volunteer in a contralateral-eye study design to determine the safety and efficacy of OPAP+ as a countermeasure (CM) for SANS-like optic disc edema (ODE) formation.

##### Study Protocol:

##### Volunteer Selection

- a. Inclusion
  - i. Healthy adult, 25–55 years
  - ii. Normal baseline ocular anatomy
  - iii. Emmetropic to mild refractive error
- b. Exclusion

- i. History of elevated ICP (e.g., idiopathic intracranial hypertension)
- ii. History of optic nerve disease
- iii. Glaucoma or ocular hypertension
- iv. History of cardiac arrhythmia, deep venous thrombosis or pulmonary embolism, myocardial infarction, stroke, seizure disorder, heart failure, peripheral vascular disease, chronic compression wound

Medical clearance by licensed Texas medical doctor (MD) to be obtained no less than 7 days prior to HDT start ensuring volunteer meets inclusion/exclusion criteria. Baseline evaluation for HDTBR to occur within 24 hours of HDT start. Study battery will be obtained: facial photos, visual acuity, color vision, visual fields, IOP, dilated fundus exam, **OCT** and MultiColor Imaging.

Exposure phase: Volunteer will remain in a strict supine 6° HDT for the first 7 days; no treatment with OPAP device. Twice daily evaluations by licensed Texas registered nurse (RN) will be performed (0800, 2100) to evaluate for abnormal cardiovascular, neurological, or dermatological changes; concerns will be escalated to MD for determination of study abort or activation of emergency medical services. Syncope or prolonged tachycardia (HR > 130 BPM for greater than 10 minutes) will result in study abort.

Countermeasure phase: Volunteer will continue 6° HDTBR following 7-day, in-mission battery. (**OCT Measure**) The eye with greatest change in peripapillary total retinal thickness ( $\Delta$ TRT) will begin OPAP+ application at +10 mmHg for 90 minutes, three times daily (0530, 1330, 2130) for the remaining 14 days of HDT. Contralateral eye serves as untreated control. At 21 days, volunteer will be placed upright for post-mission battery.

**Core Outcome Measures**

- a. Optical coherence tomography (OCT):
  - 1.  $\Delta$ TRT – Radial scan, ONH-centered
  - 2.  $\Delta$ RNFL thickness – Circle scan, ONH-centered
  - 3. Choroidal thickness

**Data Collection**

- 1. History, baseline weight
- 2. Photos of periocular face (i.e., where OPAP+ device will make contact)
- 3. Visual acuity – Using ETDRS-based acuity chart for near testing
- 4. Color vision – Ishihara plates
- 5. Visual field – Humphrey 24-2, Radius Virtual VF
- 6. IOP – Applanation & TonoPen, Eye Care
- 7. Dilated fundus exam
- 8. OCT and MultiColor Imaging – Using NASA SANS protocol

Recovery phase: Volunteer will proceed through recovery protocol consisting of assisted standing, ambulation, and light aerobic conditioning for three, thirty minute sessions within the first 24 hours following study completion. Volunteer will be assessed by MD and RN to ensure no deleterious cardiovascular or neurological effects are present. The subject should have ambulatory capacity without assistance, presyncopal symptoms, or vertigo prior to release from study.

Surveillance phase: Follow-up with ophthalmologist for ODE 2 weeks after release from study; subject to present to emergency room for any worsening of visual symptoms.

Patient to complete post-study survey at 7 days post-mission.

**7. SUB-INVESTIGATORS AND KEY PERSONNEL**

John Berdahl, MD  
 Cataract, Cornea, Glaucoma, and Refractive Surgery Specialist  
 Vance Thompson Vision

Thomas Berdahl  
 Balance Ophthalmics Researcher

Enrico Brambilla

**8. BIBLIOGRAPHY**

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