# Effects of Head Down Tilt on Intracranial Blood Volume: Preliminary Results from the SPACE-COT Study (NCT02493985)

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Cephalad fluid shifting and cerebral venous congestion in microgravity may be key factors in causing VIIP. SPACECOT (NCT02493985) is a randomized, blinded crossover design study using combined -12 ° HDT and 0.5% $CO_2$ and with brief exposure to 3% $CO_2$. We report intracranial blood volume changes using a novel non invasive technology, VIPS.

## BACKGROUND

- Up to 70% of US astronauts are reported to have variable ocular and cerebral VIIP manifestations.[1]
- $CO_2$, a potent intracranial vasodilator is reported to average at levels of 0.45% in ISS atmosphere. [2]
- Combined effects of HDT and 0.5 % $CO_2$ can be complementary in VIIP causality.
- Microgravity induced air pocketing can create microenvironments with enriched CO2 and short duration exposures can enhance VIIP pathophysiology

## VIPS

- VIPS (Cerebrotech Medical Systems Inc, Pleasanton, CA) analyzes the phase-shifts in low energy radio waves transmitted through a medium.[2,3,4](Fig 1.)
- Due to variable bioimpedance, different fluid compartments in the skull (i.e. brain parenchyma, CSF and blood) induce specific signal changes

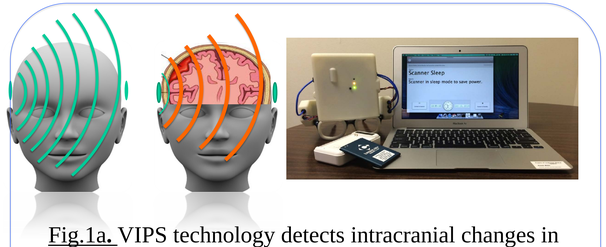

Fig.1a. VIPS technology detects intracranial changes in compartments reflected by changes in phase-shift. 1b. VIPS monitoring system (Cerebrotech Medical Systems, Pleasanton, CA)

## OBJECTIVES

1. To assess intracranial blood volume changes induced by 12 degree HDT
2. To assess combined influence of HDT and 0.5% $CO_2$ exposure on intracranial blood volume.
3. To assess the effect of acute 3% $CO_2$ induced intracranial blood volume changes

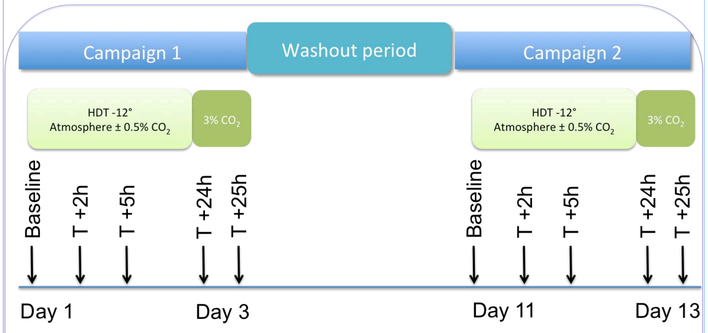


Fig 2. Schematic diagram of the study design and the times of VIPS measurement indicated by arrows. T = initiation of study condition.

## METHODS

- The study was conducted at :envihab, DLR, Cologne, Germany, approved by Baylor College of Medicine IRB and the ethics board at DLR.
- 6 healthy volunteers underwent 21±2 hours of exposure to -12° HDT with or without 0.5% $CO_2$ in two campaigns separated by a week of washout period.
- At the end of each campaign, the subjects underwent a short term 3% $CO_2$ exposure for 1 hour
- VIPS measurements were obtained at baseline, 2, 5 ,and 22±2 hours after initiation of HDT and at the end of an hour of 3% $CO_2$ exposure (Fig 2)
- Paired t-tests with multiple adjusted comparisons, and ANOVA tests were used to compare means of changes in the intracranial volumes in different atmospheres, time points and for order effects.

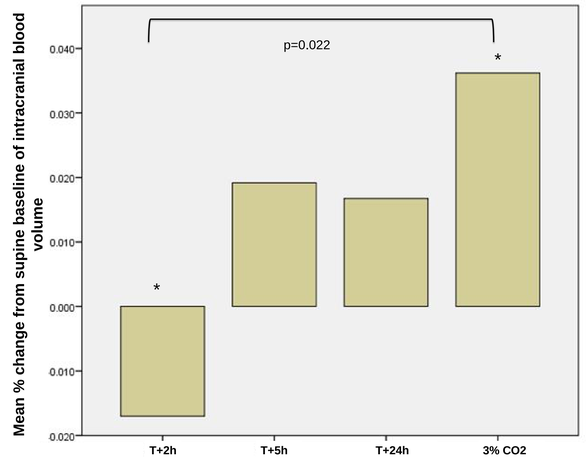


Fig.3. Changes in intracranial blood volume at different time periods in all atmospheres.

***"3% $CO_2$ inhalation produced a 5.7% increase in intracranial blood volume"***

***"The response to 3% $CO_2$ mediated increase in intracranial blood volume was blunted in subjects breathing 0.5% $CO_2$ for 24 hours when compared to 1 hour post HDT"***

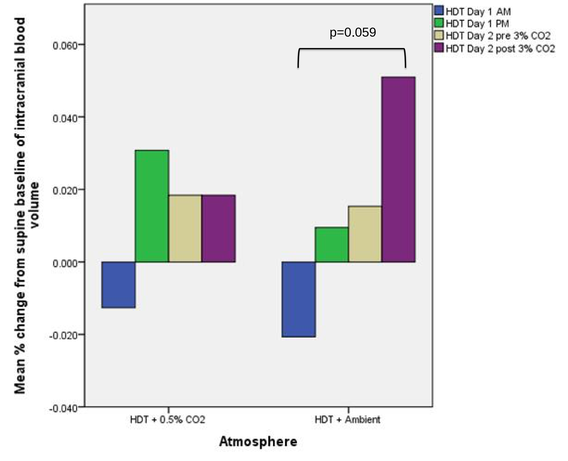


Fig.4. Intracranial blood volume changes across different atmospheres in the study.

## RESULTS

- Six healthy male volunteers completed the study protocol successfully
- Fifty nine of the 60 data points were collected. One reading was lost due to machine error.
- There was no change in the intracranial blood volume with HDT in either atmospheres (p=0.659)
- 3% $CO_2$ induced a 5.7% increase in intracranial blood volume when compared to measurements taken 1 hour post HDT in subjects under different atmospheres (p=0.022: 95% CI: 5.7-7.0%)
- 3% $CO_2$ induced increase in the intracranial blood volume was blunted when subjects were exposed to 0.5% $CO_2$ apriori when using 1 hour post HDT as the baseline(4.9% when breathing ambient air apriori as compared to 3.1% with 0.5% $CO_2$: p=0.059)
- However when measured to supine baseline, the blunted increase in the intracranial blood volumes by 3% $CO_2$ did not reach statistical significance.

## CONCLUSION

- HDT induces a reduction in the intracranial blood volume which may be likely related to cerebral autoregulation and diuresis due to body posture.
- Pre-exposure to 0.5% CO2 demonstrated a blunted response to 3% CO2 induced increased intracranial volume which could be related to a primed adaptive mechanism.
- Further analyses and studies are warranted to establish our findings.

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