Lung health in space (and on Earth)

SRS meeting 2013-03-12, Kiruna

Team members:

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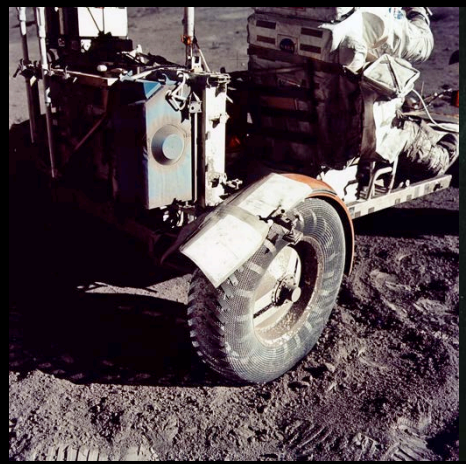
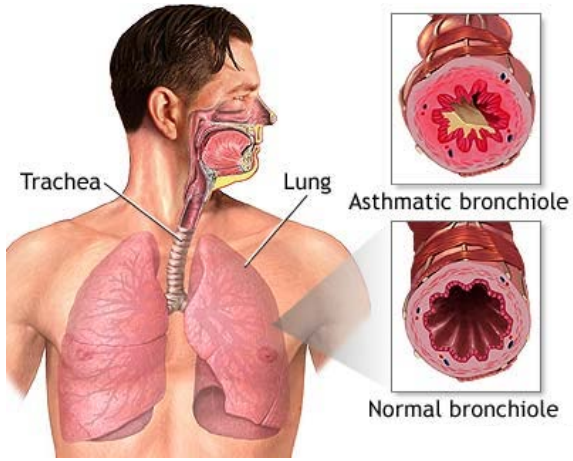


Science Background

- Inhalation of particles may have negative effects on the lungs, heart and blood vessels
- In reduced gravity there is an increased risk of inhalation of dust and free-floating particles → **airway inflammation**
- Worldwide more than 300 million people suffer from Asthma (**airway inflammation**)

Dust

Free-floating particles



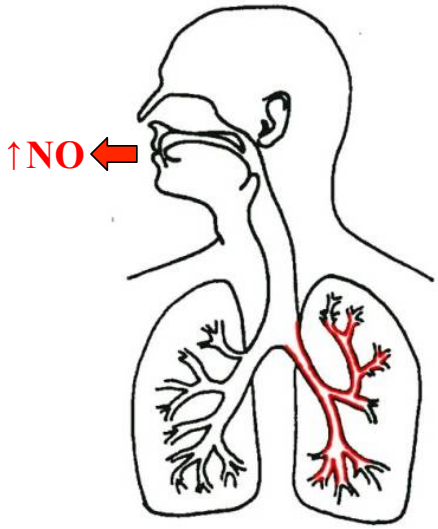
Asthma

Nitric Oxide (NO)

- Nitric Oxide (**NO**) present in vehicle exhaust, cigarette smoke, and exhaled air
- Produced in the lungs
- Dilates vessels and airways, neurotransmitter, antibacterial(?), inflammatory mediator
- Exhaled NO is an **indicator of airway inflammation**, clinically used to monitor asthma and other inflammatory airway diseases

→ Exhaled NO - a good tool for monitoring lung health in space!

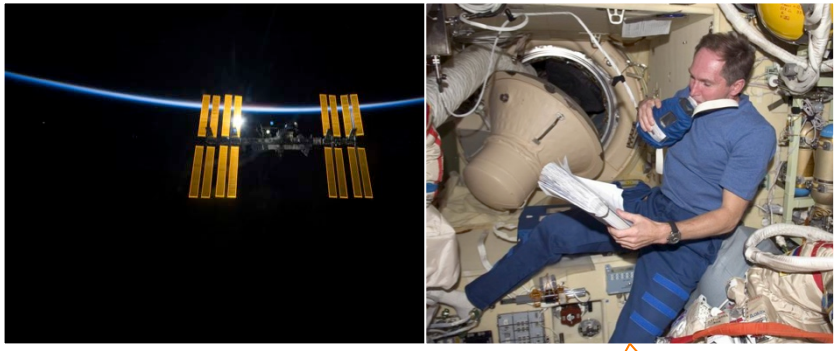
→ Baseline needed!



Airway inflammation

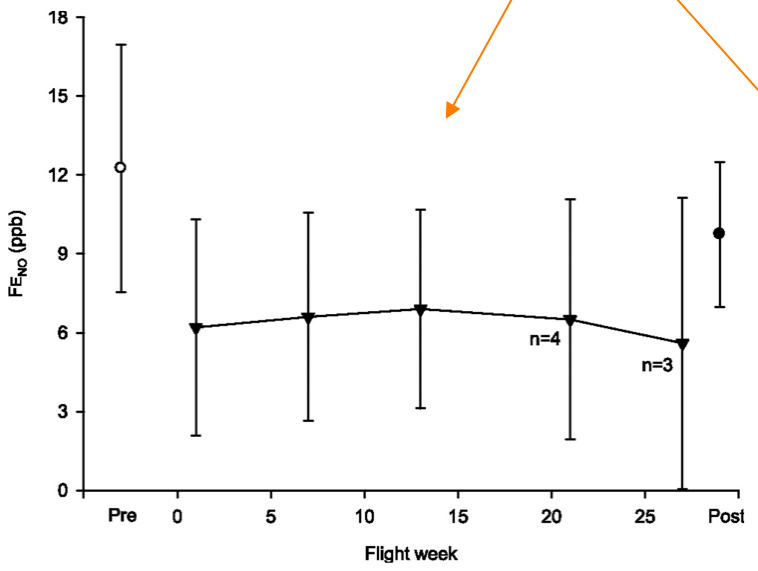

Exhaled NO in cpace

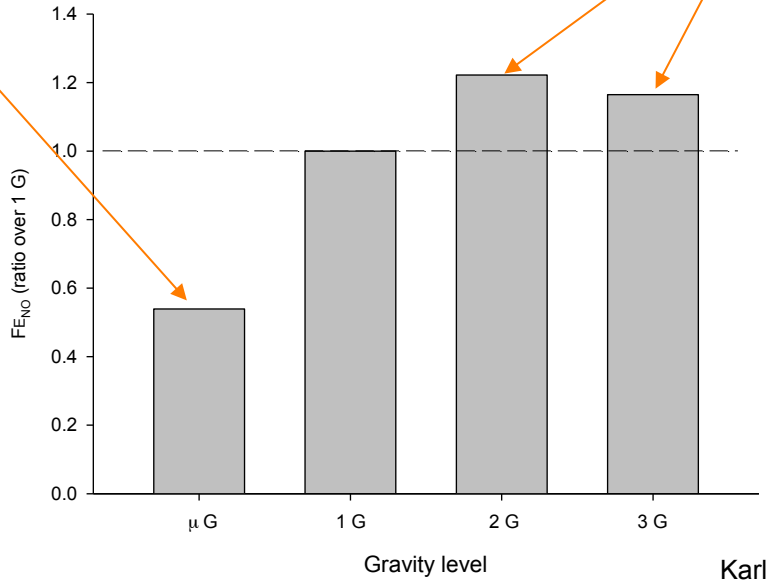
Previous results: Gravity effects



International Space Station

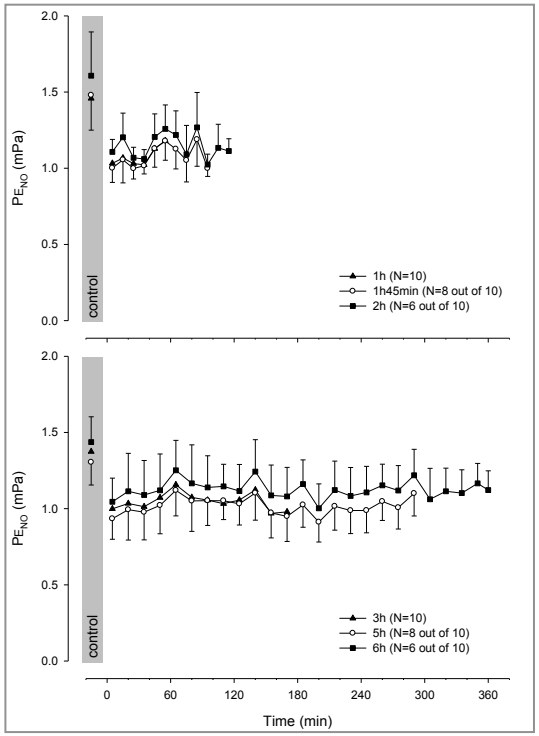
The human centrifuge at Karolinska Institutet



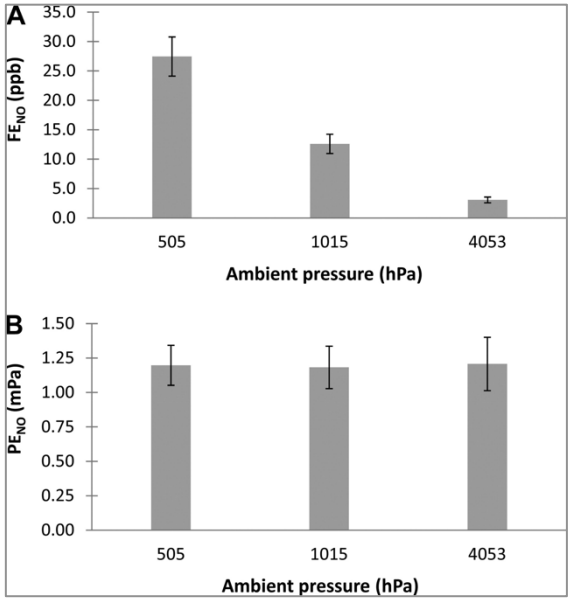


Karlsson et al., 2009

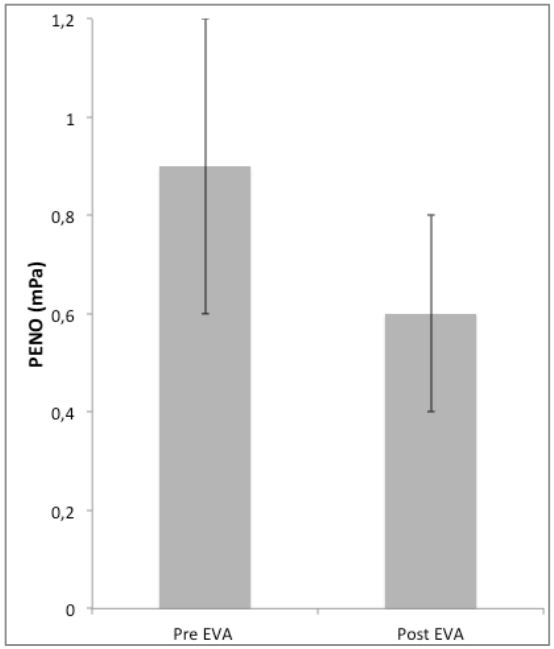
Previous results: Pressure effects



Karlsson et al., 2009



Hemmingsson et al., 2011



Karlsson et al., 2009

Scientific Objectives

For crewmember health during space missions

- Future space vehicles and planetary habitats are likely to be operated at **reduced ambient pressure** and reduced oxygen pressure.
- Lunar dust considered very toxic .

1. Study exhaled NO in microgravity
2. Study exhaled NO in microgravity combined with reduced ambient pressure

→ use exhaled NO to monitor airway health in future space mission

First microgravity tests, july 2005

Valery Tokarev, ISS october 2005

Previous hypobaric tests on Earth

Scientific Objectives (contd.)

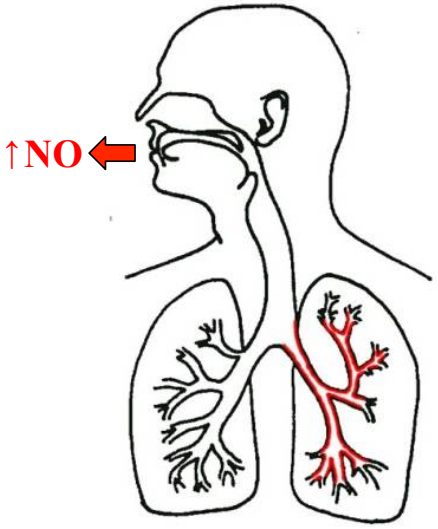
For lung health on Earth

Exhaled NO is clinically used to:

- diagnose Asthma and other inflammatory diseases
- aid the selection of medication
- monitor treatment success

3. Study the lung NO turnover within the unique microgravity environment on ISS

   → *improve the clinical use of exhaled NO*



Experiment overview

Exhaled NO is influenced both by gravity and ambient pressure, and the combined effects are not known

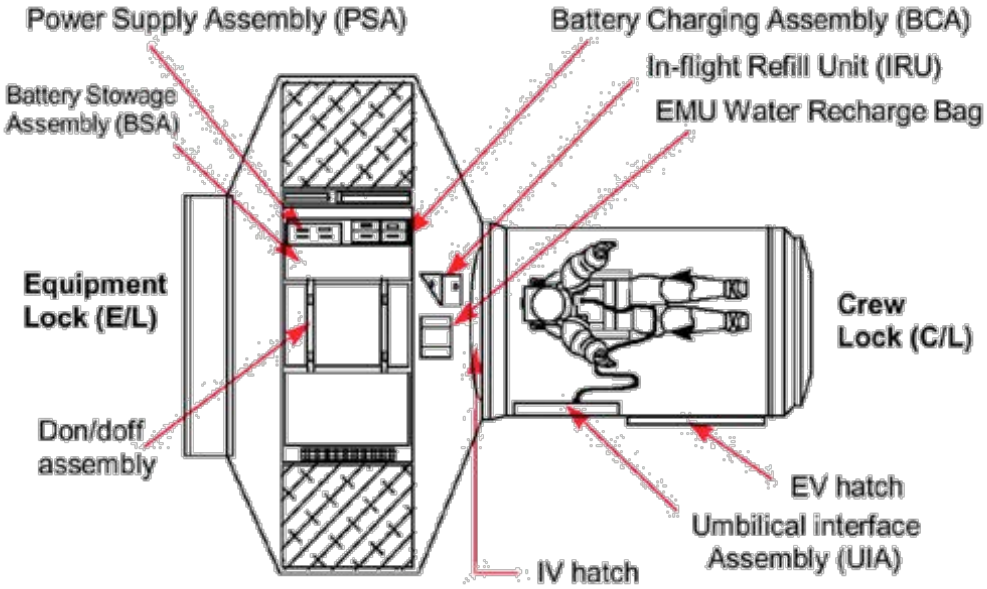
- Experiment to be performed with astronauts as subjects before and during the first four months of ISS missions
- Experiment operations are planned at normal and at **reduced ambient pressure** (1000 hPa and 700 hPa / 3000 m alt. respectively)
  - → Preflight baseline data collection performed in a hypobaric pressure chamber
  - → Inflight hypobaric tests will be conducted in the US airlock
- Following variables are measured:
  - → Exhaled NO at 3 different flows (nominally 30, 90, and 300 ml/s)
  - → Lung NO diffusing capacity (the lungs ability to transfer gas from air to blood)
  - → Other gas concentrations, flow, pressure, etc.

US airlock

First time ever experiments at reduced pressure

Hardware inflight

Niox Mino and PPFS during fit-check in Equipment Lock mock-up

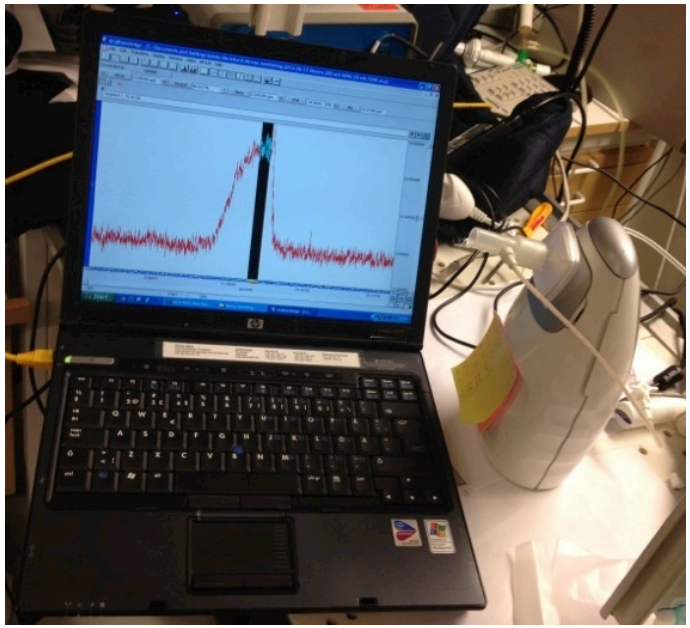


- NO analyzers
- Pulmonary Function System
- Gas supply: Gas mixture 1: 1% SF_6 in 21% O_2 and rest N_2
  Gas mixture 2: 400 ppm NO in N_2
- Gas mixing bags
- Other consumables, such as mouth pieces, cleaning wipes, etc.

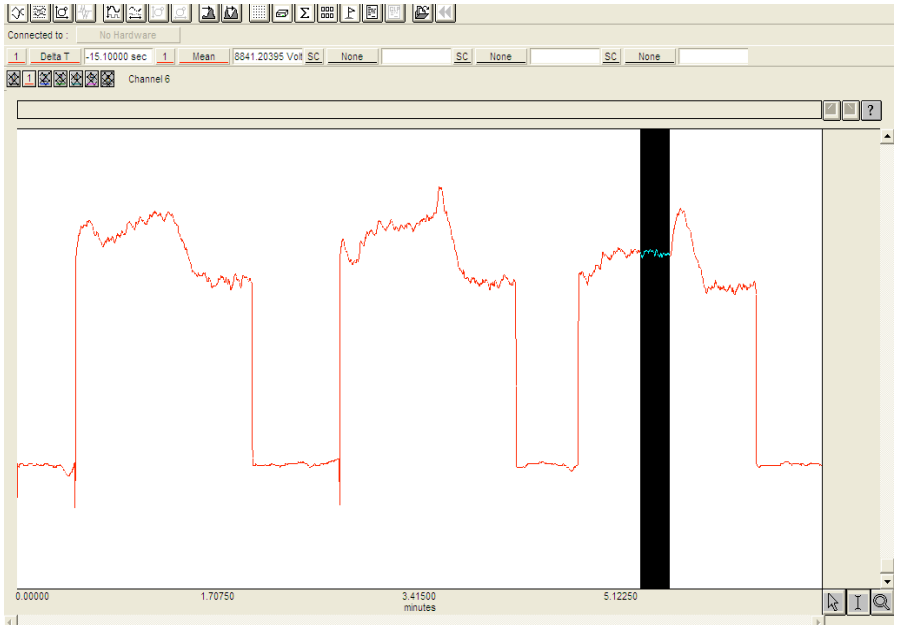
Hardware: NO analyzer

- Modify commercially available NO analyzers (started as an ESA MAP project).
- Extract the “real-time” sensor NO raw signal → better and more accurate analysis, less artifacts.

NO-Analyzer Niox Mino



Real-time NO analysis (Sievers 280 Nitric Oxide Analyzer)



Sensor “real-time” raw signal from Niox Mino

Hardware: Portable Pulmonary Function System (PPFS)

Combined with NO analyzer for:

- Exhaled NO measurements
- Lung NO Diffusing Capacity measurements (gas to blood transfer)

- Already aboard ISS

Portable Pulmonary Function System - PPFS

Experiment Design Overview

Preflight	Inflight	Postflight
L-150 to launch: Three preflight BDC sessions*, each including measurements at normal and reduced air pressure (14.7 and 10.2 psi), each session is 150 min plus travel time (190 min total). A hypobaric chamber will be used for the measurements at reduced pressure levels.	**FD 1-60** and **FD 61-120:** One session at normal ISS air pressure, and one session at normal and reduced air pressure (14.2 and 10.2 psi). Combined (normal and reduced pressure) session inside US Airlock.	No postflight testing.
Total Time: 570 min (9 hours, 30 min)	**Total Time: 1290 min (21 hours, 30 min)****	

* Third preflight BDC session can be waived if data of first two sessions is consistent

** Time estimate includes time for preparation of airlock

History and future

- Swedish ethical approval – 2009
- ESA International Life Science Research Announcement (ILSRA)
  - → Submitted and selected in 2009
- Ground based experiments – 2009 and forward
- Experiment Scientific Requirements (ESR) – approved 2011
- Medical board approvals:
  - → ESA Medical Board – 2011
  - → NASA Medical Board – 2011
  - → JAXA Medical Board – 2011
  - → Human Research Multilateral Review Board (HRMRB) – 2012
- Hardware and software development contract – 2012
- Informed Consent Information Presentation – March 2013
- - - -
- First hardware tests – June 2013
- Launch of test gases and hardware 2013/2014
- First subjects March 2014 (Increment 39/40)
- Parallel ground based supporting experiments
- Continuous SNSB support throughout the project

Coming subjects (hopefully!)

Gregory R. Wiseman

NASA astronaut

Nationality	American
Status	Active
Born	November 11, 1975 (age 37) Baltimore, Maryland
Other occupation	Test pilot
Selection	2009 NASA Group

Alexander Gerst

ESA astronaut

Status	Active
Born	May 3, 1976 (age 36) Künzelsau, Baden-Württemberg, Germany
Selection	2009 ESA Group
Awards	Bernd Rendel-Preis

Terry W. Virts, Jr.

NASA Astronaut

Nationality	American
Status	Active
Born	December 1, 1967 (age 45) Baltimore, Maryland
Rank	Colonel US Air Force
Selection	2000 NASA Group
Missions	STS-130
Mission insignia	

Samantha Cristoforetti

ESA astronaut

Status	Active
Born	April 26, 1977 (age 35) Milan, Italy
Other occupation	Italian Air Force
Rank	Captain
Selection	2009 ESA Group