Acceleration Atelectasis in the F-22

Return of an ‘old friend’

Lt Col Jay Flottman,
USAF F-22 Pilot-Physician
Disclosure Information

I have no financial relationships to disclose.

I will not discuss off-label use and/or investigational use in my presentation.

This presentation contains the opinion of the author and does not reflect the view of the U.S. Air Force or Department of Defense.
Overview

• Historical literature review
• Acceleration Atelectasis – definition
• F-22 OBOGS Review
• Upper Pressure Garment Review
• Personal History
Historical Literature Review (sample)

- Ernsting, J. *Some Effects of Oxygen Breathing*, Proceeding of the Royal Society of Medicine, 1960
- Balldin UI. *Pressure Breathing and Acceleration Atelectasis*. Raising the operational ceiling. A workshop on the life support and physiological issues of flight at 60,000 and above, June 1995
Acceleration Atelectasis

- Collapse of alveoli in the dependent lung due to increased accelerative forces
- Symptoms – cough, inability to take a deep breath, pain in the chest (Keefe, 1958)
  - May last minutes to several hours (Balldin, 1995)
Atelectasis Cont.

• Glaister reported three conditions required for development of Atelectasis (AGARD, 1970):
  – Acceleration, elevation of the diaphragm (Anti-G Suit), 100% Oxygen

• Reduction of incidence recommended 40% Nitrogen for air mixtures up to 25,000 ft cabin altitude (Ernsting, 1963)
Atelectasis Cont.

- Life Support System Task Force (LSS) further identified specific factors in the F-22 (see flow diagram) that may have been contributing factors.
Atelectasis Cont.

• “We believe there is a certain amount of atelectasis. If we conduct the study that Dr. Balldin is suggesting relating to assisted PBG, I think the fit and tightness of the Jerkin will be critical,” (Ackles, 1995)
F-22 OBOGS Review

O2 System Comparison, Source O2 Concentration to Mask

Transition to MAX at 11K Cabin Altitude
• UPG is designed to inflate during Positive Pressure Breathing (PPB) only
• During non-PPB operation, UPG should not inflate
• Test results show UPG fills and retains BRAG safety pressure at all times
• UPG pressure is often above mask pressure
• Pilots are forced to breathe against UPG restriction
Upper Pressure Garment
Breathing Changes

- UPG causes pilots to adjust their breathing patterns
  - F-22 Baseline w/o UPG had higher peak flows than F-22 Baseline (w/UPG) for similar inhalation cycles
  - UPG restricts pilot peak flow rate by one third
  - UPG restricts thoracic expansion
  - To maintain a similar tidal volume, the pilot must inhale longer

F-22 Baseline (w/ UPG) vs. F-22 Baseline w/o UPG, Pressure – Flow Comparison
Personal Testimony

- April 2012 – “Red-Air” F-22 Sortie, Elmendorf
  - Cold WX gear including undergarments, ATAGS, UPG, C2A1 canister, finger-mounted pulse oximeter, survival vest, MAX OBOGS selection with mask up from start to shutdown
Personal Testimony

• April 2012 – “Red-Air” F-22 Sortie, Elmendorf
  – Cold WX gear including undergarments, ATAGS, UPG, C2A1 canister, finger-mounted pulse oximeter, survival vest, MAX OBOGS selection with mask up from start to shutdown
  – Relatively low G; 2-3 x high G turns (+6-7G) lasting only few seconds
  – Less than 1.5hr mission
  – Post flight: inability to breathe deeply without substernal chest pain (pain lasted 3-4 hours), pulse ox drop to 94-95% immediately post-flight that lasted 2-3 minutes, minor cough

• Classic symptoms per original literature reviews (60’s and 70’s) – discussed with Boeing Led Physiology Team during Physiologic Event Investigation
Take Away

• Need to further explore AFE fitting procedures
• Placement of AFE on the torso (i.e. survival vest)
• AFE in general – was it contributing to the symptoms that had been reported by pilots in the field?
• Importance of HSI in life support equipment development