Topics in Aviation Medicine
EBACE Geneva 2007

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- Cosmic radiation
- Deep vein thrombosis
- Cabin air quality
- Human factors
Galactic Cosmic Radiation
- Production & Attenuation with Altitude

40 km
Satellite

20 km
Balloons

10 km
Supersonic

1 km
Subsonic
High Peaks
GCR Barriers: Solar Cycle Effects

GCR intensity anticoincident with solar cycle
GCR Barriers: Earth’s Magnetic Field

- Earth’s magnetic field deflects incoming galactic radiation particles.
- Shielding provided by magnetic field greatest at the equator and disappears over geomagnetic poles.
Dose Rate Increases with Altitude and Latitude

Altitude

Count Rate

Constant Latitude

Heading North

Dose Rate Increases with Altitude and Latitude
Biological Effects of Ionising Radiation

- Very high levels (nuclear explosion) –
  - Cell Death

- Low levels (cosmic rad, medical X rays) –
  - Self repair
Variation of Particle type with Altitude

- Muons
- EM Showers
- Protons
- Charged Pions
- Neutrons

Altitude (ft)

Percent of Total (%)
Health Risks of Cosmic Radiation

Cancer

- Development dependent on energy & dose

- 5mSv per year for 20 years (long haul crew)
  - Risk 0.4%

- Overall risk in Western population 23%
  - Risk of cancer death increased from 23% to 23.4%
Health Risks of Cosmic Radiation

- **Risk of inheriting radiation-induced genetic defect**
  - 1 in 2,500 for accumulated dose of 5mSv over 20 years
  - Background incidence in general western population 1 in 50, with 2-3% liveborn children having one or more severe abnormalities at birth.
Health Risks of Cosmic Radiation

Risk to health of foetus

- Cancer and mental retardation
- Risk increases by between 1 in 6,000 & 1 in 30,000 from exposure to cosmic radiation for 80 block hours flown in one month, depending on routes flown.
- Significant background rate within general population.
Health Risks of Cosmic Radiation

Eye Cataract

- 2005 Iceland study concluded pilots have increased risk of developing cataracts
- 2006 Germany study showed that commercial pilots had fewer cataracts than expected for age group
Health Risks of Cosmic Radiation

- Cataract
  - Lens ages, protein structure changes, lens opacifies
  - Lens ageing accelerated by
    - Malnutrition
    - Dehydration (central, not peripheral)
    - Diabetes
    - Sunlight
    - Smoking

No causative link demonstrated in airline pilots with cosmic radiation exposure
ICRP 60 Recommendations (1991)

- Adopted by most countries

- Dose limits
  
  20 mSv y\(^{-1}\) : Occupationally exposed
  
  1 mSv y\(^{-1}\) : Public (includes foetus)

- Recognize Aircrew as Occupationally Exposed

- To natural radiation
96/29 EURATOM

Directive from the European Commission

- Binding on member states
- Implementation date
  - 13th May 2000
96/29 EURATOM

Each Member State shall make arrangements for undertakings operating aircraft to take account of exposure to cosmic radiation of air crew who are liable to be subject to exposure to more than 1 mSv per year. The undertakings shall take appropriate measures, in particular:

• to assess the exposure of the crew concerned
• to take into account the assessed exposure when organising working schedules with a view to reducing the doses of highly exposed air crew
• to inform the workers concerned of the health risks their work involves
• to apply Article 10 to female air crew
Regulated Exposure

Classified worker under European Ionising Radiation Regulations -

3/10 occupational exposure limit
i.e. 6 mSv y\(^{-1}\)

(No radiobiological significance)
GCR Exposure Calculation

- **Input**
  - Altitude
  - Solar cycle
  - Latitude & longitude

- **For a flight, integrate over the route with**
  - Dates
  - Airports
  - Flight profile

- **Theoretical or Experimental**
  - Validation
Commercial Aircrew Survey
(1996-98)

ATDE (mSv)

Intervention Level
Previous Public Limit

Current Public Limit

Aircrew

Flight Attendant  Pilot  Air Crew
British Airways

Average dose rates

- Concorde: 12-15 μSv/hr
- Long haul: 5 μSv/hr
- Short haul: 1-3 μSv/hr

Expected annual exposure

- Long haul: 4 mSv/yr, 20% of annual dose limit
- Short haul: 2 mSv/yr, 10% of annual dose limit
Annual Occupational Exposures*

*Occupational exposures do not include radiation from medical procedures or from the natural background (Data from 99-EHD-239)
Epidemiology

British Airways flight crew 1950 - 1992

- 6209 pilots, 1153 flight engineers
  - 143,500 person years of observation
- Life expectancy at age 55 - 65
  - 4 - 5 years better for long haul crew
  - 2 - 3 years better for short haul crew
- Cases of leukaemia less than expected
- No excess of cancer apart from melanoma
  - Comparable with other studies
Cosmic Radiation

- General Public limit 1 mSv y\(^{-1}\)
  - [Concorde : \(\sim 100\) h y\(^{-1}\)]
  - Trans-equatorial sub-sonic : \(\sim 200\) h y\(^{-1}\)

- Trans-Atlantic : 8 return flights
- Antipodean : 5 return flights
Cosmic Radiation

- Occupational Exposure limit 20 mSv y\(^{-1}\)
  - [Concorde: \(~2000\) h y\(^{-1}\)]
  - Trans-equatorial sub-sonic: \(~4000\) h y\(^{-1}\)

- Trans-Atlantic: 160 return flights
- Antipodean: 100 return flights
Cosmic Radiation

- UK Occupational Control limit 6 mSv y\(^{-1}\)
  - [Concorde : \(\sim 600\) h y\(^{-1}\)]
  - Trans-equatorial sub-sonic : \(\sim 1200\) h y\(^{-1}\)

- Trans-Atlantic : 48 return flights
- Antipodean : 40 return flights
Galactic Cosmic Radiation is a natural part of air travel.

Assessment of occupational exposure is required to comply with Euratom Directive.

Dose is a function of altitude, latitude, time and solar cycle.

Travellers unlikely to be at increased risk.
STRUCTURE OF ARTERIES AND VEINS

Arteries have thick muscular walls which help in controlling the flow of oxygenated pressurized blood from the heart. The veins require valves to help move deoxygenated blood back to the heart as it is no longer under sufficient pressure and is moving against gravity. The capillaries distribute the nutrient-carrying blood to all the body's tissues and organs.
Blood vessels shown in red are the principal arteries and conduits carrying freshly oxygenated blood from the heart throughout the body.

Blood vessels shown in blue are the principal veins bringing de-oxygenated blood from the body to the heart.
- Virchow, 1856
- Simpson, 1940
- Homans, 1954
  - 5 cases of DVT after prolonged sitting
    - car trip 2; prolonged flight 2; visit to theatre 1
- Cruikshank, 1988
  - 3 case reports of DVT after flying
  - coined the phrase ‘economy class syndrome’
    - 1 case travelled business class, 2 cases were doctors
      - could equally well have described it as ‘travelling doctor syndrome’ (Kesteven, 2000)
Kesteven, 2000

- over 12 month period, every case of VTE in population of 650,000 in north of England was asked about travel in 4 weeks before diagnosis
  - 26 cases identified out of 634 cases of VTE
    - 16 followed a flight
    - incidence **0.4 /10 000**
  - 66% cases precipitated by the homeward leg of the journey
  - majority of cases present within 96 hours of travel
Is the flight environment a factor?

- low humidity
  - comparable to Arizona/Middle East
- relative hypoxia from cabin altitude
  - comparable with NBO/JNB/DEN
- seated immobility
  - is a known risk factor for VTE
- Incidence of traveller’s thrombosis
  - incidence of DVT in general population
    \[1/1000/\text{yr}\]

- What is the risk?
  - without additional risk factors
    \[1\text{ in } 2\ 000\ 000\]
  - with additional risk factors
    \[1\text{ in } 100\ 000\]
In subjects with no obvious risk factors

- drink adequate fluids
- avoid smoking and alcohol
- walk around regularly
- carry out foot and leg exercises
- avoid crossing legs when seated
- wear loose fitting clothes
Crew concerns about exposure to toxic substances

• ~14,500 professional licence holders in UK
  – CAA medical database: 10 pilots who believe their ill health caused by cockpit air contamination
  – BALPA reports: database not systematic
• Increase in reports since 1999
  – Why?
Scientific method

Minimise personal and cultural bias and prejudice –

• Observation, measurement, description of a phenomenon
• Development of hypothesis to explain phenomenon
• Make predictions using hypothesis
• Test the hypothesis by independent experiment
Observations

- Individual variability and sensitivity
- Bad smell does not necessarily mean presence of harmful substance
- Equally, absent smell does not mean absence of harmful substance
- Reported symptoms and signs can be associated with wide range of conditions
  - Hypoxia, hyperventilation, anxiety, stress, chronic fatigue, viral infection, post viral fatigue syndrome, ME, etc.
  - 70% of the population are known to experience one or more of the symptoms on any given day
Blood tests

• Difficult to interpret
• Antibodies to nervous system proteins are present in large percentage of normal population
• Lack of clarity in what are ‘normal’ values
• Exposure of farmers to organo-phosphates in sheep dip not comparable to postulated inhaled OPs in cabin air
Neuro-psychology

- Australian report showed ‘cognitive impairment’ of exposed crew members
  - Poorly designed study
    - No suitably matched controls
    - Pilots self-selected for study
- Difficult to disentangle physical, psychological and emotional components of well-being
- Bigger study needed
Scientific studies

- British Airways – independent review completed
- CAA – independent review completed
- UK Committee on Toxicology – review in progress
an actual drawing, handed to a flight attendant on a Quantas flight by an 8 yr old girl

dear Captain
My name is Nicola I'm 8 years old, this is my first flight but I'm not scared. I like to watch the clouds go by. My mum says the crew is nice. I think your plane is good. thanks for a nice flight don't fuck up the landing.

LUV Nicola
XXX