RETURN ADDRESS:
Editor, Alberta Occupational Medicine Newsletter
Dept. of Community Health Sciences
Faculty of Medicine
University of Calgary
3330 · Hospital Drive N.W.
Calgary, Alta., T2N 4NI Canada

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ALBERTA OCCUPATIONAL MEDICINE NEWSLETTER

EDITORIAL COMMENTS

This edition of the Newsletter begins with an article by Dr. Gary Butler, presently a first-year medical student at the University of Calgary. His doctoral thesis investigated cardiovascular and autonomic control processes in microgravity environments. As he describes, cosmic and solar radiation exposure at ground level is much less than that received from terrestrial sources and radon. For flight crew personnel spending most of their working hours at high altitudes, however, exposure to ionizing radiation can be substantial. As well, there is a concern that sleep and circadian rhythm disturbances caused by international flights may increase susceptibility to certain cancers, in particular melanoma.

At the Annual Meeting of the AMA Section of Occupational Medicine on October 18, 2000 (held in conjunction with the OEMAC 2000 Conference in Banff, Alberta) members voted to provide funding for the Newsletter, to complement that provided through a medical education grant from Workers' Compensation Board Alberta. We are now able to provide a modest honoraria for keynote articles (as described in more detail in this issue). We hope, too, that the Newsletter will better serve the communication and educational needs of Section members, and other occupational physicians in Alberta.

In the hope that this edition reaches your mailboxes before Christmas, we wish all our readers the best for the holiday season and the New Year.

Kenneth Corbet, MD, FRCPC
Editor

Kim Blaikie, RN
Project Assistant

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FLIGHT DECK OCCUPATIONAL EXPOSURES

Gary C. Butler, PhD*

Introduction

Scientists have known since 1907 that radiation originating outside the earth's atmosphere causes increasing biological effects as altitude above sea level increases. Modern scientists generally believe that stellar flares, stellar coronal mass ejections, supernova explosions, pulsar acceleration, or galactic nuclei explosions produce and accelerate this radiation, called cosmic radiation. Radiation is transmitted through space in the form of photons or subatomic particles. Cosmic radiation is a mixture of various types of "ionizing radiation"-a term used if the photons or particles produce, in the material irradiated, one or more ions, or electrically charged atoms or group of atoms. Ionization is the primary process by which radiation exposure affects biological organisms. Aircrews, while flying, are exposed to levels of cosmic radiation that are greater than ground levels received from both cosmic and terrestrial radiation.

Galactic radiation

At airliner flight altitudes, high-energy subatomic particles-primarily protons (95 percent), alpha particles (3.5 percent), and heavier nuclei are

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and the Section of Occupational Medicine, Alberta Medical Association

colliding with and disrupting atoms of nitrogen, oxygen, and other elements of the atmosphere. These collisions produce photons and additional subatomic particles, which are referred to as galactic cosmic radiation. The number of galactic radiation particles entering the atmosphere (and the radiation level at airliner flight altitudes) varies with the I 1 -year cycle of rise and fall of solar activity. Magnetic fields, which are associated with low-energy subatomic particles (solar wind) that the sun continuously emits, deflect lower-energy galactic particles that would otherwise enter the atmosphere; this causes the variation in the amount of galactic radiation. The solar wind particles are in themselves too low in energy to affect the amount of radiation at flight altitudes.

Variation with latitude and altitude

Earth's geomagnetic field provides some protection from incoming cosmic radiation, deflecting the incoming cosmic rays, depending on their angle of incidence and rigidity (defined as the momentum per unit charge of cosmic ray particles). For each angle of incidence, the incoming particle has a critical rigidity below which it cannot reach Earth's atmosphere. The greatest protection is above the geomagnetic equator (near the geographic equator) and decreases to zero as one approaches the North or South Pole. Therefore, at any given cruise altitude, the galactic radiation dose-rate increases with distance north or south of the equator until it plateaus at high latitudes. In the northern hemisphere, at a constant altitude, the galactic radiation level shows little or no increase above 50 degrees latitude in North America and 60 degrees in Europe and Asia. Amounts of radiation levels above the Poles at airliner cruise altitudes are twice those above the equator at same the altitudes. Earth's atmosphere provides significant shielding from cosmic radiation. The lower the altitude, the thicker the atmospheric layer and, therefore, the greater the protection.

Solar flares

A solar flare is an intense magnetic disturbance on the sun, resulting in an explosive emission of various kinds of radiation. During some solar flares, the number and energies of particles emitted from the sun may temporarily become high enough to significantly increase the amount of ionizing radiation at flight altitudes, particularly over the polar regions. Until very recently, solar flares that would emit particles could not be predicted reliably nor could one predict how far the radiation would reach, even after the event had occurred. However, NASA, using the Japanese Yohkoh spacecraft, discovered that S-shaped sigmoid patterns often appear on the surface of the sun before these violent solar eruptions. NASA's data indicate a strong correlation between an S-shaped pattern on the sun and the likelihood that an eruption will occur in that region within days.

At altitude, the radiation resulting from solar flares is produced in the same way as galactic cosmic radiation is produced. The particles from the sun, as well as the photons and particles they produce in the atmosphere, are referred to collectively as solar cosmic radiation. Between 1956 and 1991, inclusive, approximately 6 solar particle events occurred during which the radiation at 41,000 feet above the polar regions probably rose to more than 100 microsieverts per hour. The normal radiation level at these locations is approximately 12 microsieverts per hour.

When considering health effects of ionizing radiation, the amount of radiation that an individual receives is expressed in terms of sieverts. The sievert is a measure of the biological harm that ionizing radiation may cause and is the current international unit for this measurement. The sievert replaces the rem: I sievert=I 00 rem

Effective dose: When irradiation of the body is not uniform, the effective dose is an approximately uniform whole-body dose that would result in the same risk of cancer, hereditary effects, and length of life lost as the nonuniform exposure. When irradiation of the body is approximately uniform, the dose and effective dose are the same.

Radiation exposure and recommended limits

The U.S Federal Aviation Administration (FAA) has estimated the amount of galactic radiation that aircrew members receive on a wide variety of routes to, from, and within the contiguous United States. Cumulative dosage, of course, will vary depending on altitude, latitude, and duration of flight on the route flown. At the present stage of the solar cycle, the galactic dose ranges from 0.023 to 0.80 millisievert per 100 block hours. For example, based on 0.60 mSv per 100 block hours (the mean for a New York City to Athens, Greece, flight), a pilot flying 700 block hours a month would receive an annual occupational exposure of 4.2 mSv. In contrast, a pilot flying 700 block hours on a Chicago-to-San Francisco route (0.41 mSv/IOO block hours) would receive an annual dosage of approximately 2.8 mSv. Typically, cosmic radiation exposure for airline pilots in North America ranges from 3 to 5 millisieverts annually. These values are considerably lower than the occupational limit of 20 millisieverts per year (S-year average) than the International Commission on Radiological Protection (ICRP) recommends for a nonpregnant adult.

Considerations during pregnancy

Some recommendations concerning exposure apply only to pregnant women. The ICRP recommends that once a woman learns she is pregnant, her occupational exposure to ionizing radiation should not exceed I millisievert for the remainder of the pregnancy. Further, the exposure of the unborn child should not exceed 0.5 millisievert in any month (excluding medical exposures), once a pregnancy becomes known. For radiation protection purposes, the unborn child is assumed to receive the same dose of cosmic radiation as the mother; but on some flights, the galactic radiation that an unborn child receives may exceed the recommended limits. For example, consider two flights: a long (9.5 hours) New York-to-Athens flight and a short (0.5 hour), low-altitude flight from Houston to Austin, Tex. The effective dose from the long-haul flight is approximately 64 microsieverts ((Sv),

whereas the effective dose from Houston to Austin is only about 0.14 microsieverts. The long-haul pregnant pilot will clearly exceed the 1 mSv limit (64 (Sv equals 0.60 mSv/lOO block hours/month). Working on short, low-altitude flights, or alternately, being assigned to a ground position for the remainder of the pregnancy, could reduce a pregnant pilot's exposure.

All flightcrew members can calculate their cosmic radiation dose using the FAA computer program CARI-5E. A free download is available through the Internet at *http://www.cami.jccbi.gov/research/610 /6OOradio. html*

Health concerns

The health concerns from cosmic radiation to aircrew members are cancer, genetic defects that can be passed on to future generations, and harm to an unborn child. Cancer is the primary health risk associated with occupational exposure to ionizing radiation; damage to genetic material in the cell is thought to be the mechanism that underlies the increased risk of cancer. The career risk to aircrew members of dying from cancer is slightly higher than the general population, as are the risks for genetic defects and for harm to an unborn child. Research projects investigating health effects in aircrews caused by cosmic radiation exposure are relatively few. Generally, while these studies have reported some excess cancers, their results are far from definitive.

ALPA Flight Deck Occupational Exposure Project

At present, although one cannot exclude the possibility of harm from exposure to cosmic radiation received during a career of flying, establishing that an abnormality or disease in a particular individual resulted solely from radiation exposure is impossible. Cosmic radiation is but one of several environmental stressors that affect pilot health. Among the physiological challenges to the long-term health of an airline pilot are circadian dysrhythmia, reduced atmospheric pressure, mild hypoxia, low humidity, noise, vibration, cosmic radiation, and magnetic fields. Given the complexity of an airline pilot's environment and the possibility that two or more of the stressors might work together to cause more harm than each would separately, comprehensive research into both cosmic radiation and magnetic field exposures in airline pilots is needed now. However, studies of how radiation affects airline flight crews are confronted with several challenges. First, one must deal with the possibility that both ionizing and nonionizing radiation (magnetic field) enhance the harm inherent in several other occupational exposures. Second, as health effects among flightcrew members are small, detection will be difficult. Third, access to a large population of airline pilots has been traditionally difficult to secure. Fourth, actual measurement of cosmic radiation doses is not yet on solid ground, which may result in a misestimation of doses. And fifth, any discussion of potential ionizing radiation risk and/or cancer incidence assessment must include biological markers of past cosmic radiation exposure.

Since 1997, the Air Line Pilots Association (under the direction of Dr. Gary C. Butler), in conjunction with the Medical University of South Carolina (Department of Biometry and Epidemiology; Dr. J. Nicholas and Dr. Dan Lackland), has initiated an extensive research program into these occupational exposures. The Civil Aeromedical Institute of the FAA (Dr. Wallace Friedberg) has also been involved. Studies have included the following:

- Ground-based calculations of cosmic radiation
- Quantifying magnetic field exposure on the flight deck
- Undertaking epidemiological survey and exposure assessment.

The epidemiological study had three primary objectives:

1. Assess cancer incidence in a large group of U.S. and Canadian airline pilots, through a health survey sent to approximately 9,000 active and 1,000 retired Delta pilots and to 1,300 active and 350 retired Canadian Airline pilots.
2. Construct an extensive database on flight dosage rates, based on a flight history survey.
3. Analyze the relationship between exposure to cosmic radiation and the presence of specific medical conditions.

Detailed results of this study (available in early winter 2001) should provide comprehensive data on cancer risk and ionizing radiation. In particular, we will report a 3.47 (standardized incidence ratio (SIR)) increase in self-reported melanoma compared to United States SEER data, adjusted for age and controlled for race and gender. It has been suggested that the high incidence of malignant melanoma may result from intermittent and intense sun exposure habits (linked with high social class, high education and affluence), exposure to cosmic radiation, and circadian rhythm disturbance. In. general, risk does not correlate with cumulative sun exposure but may relate to sun exposure (especially a blistering sunburn) in childhood (Bickers, 1998). Incidence is inversely correlated with the latitude of residence. The individuals most susceptible to development of melanoma are those with fair complexions, red or blond hair, blue eyes, freckles, and who sunburn easily. Other factors associated with increased risk are a family history of melanoma, the presence of clinically atypical moles, and immunosuppression (Sober, 1998). However, it should be noted that there have been no studies that have yet documented the sun-exposure habits of pilots. The high incidence of melanoma in pilots has also been related to exposure to cosmic radiation. Again, there are no consistent cancer patterns on exposure rates to cosmic radiation and malignant melanomas (Rafnsson et al, 2000, Gundestrup and Storm, 1999; Kendall et al, 1992).

A recent study (Rafnsson et al, 2000) concluded that the incidence of malignant melanoma was highest among pilots who had flown routes that extended over multiple time zones causing disturbance of circadian rhythm. It is suggested that immune system function may altered by changes in the homeostasis of melatonin. As melatonin has been reported to have cancer protective qualities, any regulation of melatonin may increase susceptibility to melanoma. Further research in needed in this area, in particular to investigate the effect of

chronic fatigue on immune system function as well as to investigate the potential synergies of cosmic radiation, disturbed circadian rhythm, and excessive sun bathing. It is of interest that exposure to solar radiation influences local and systemic immune responses. UV-B seems to be the most efficient in altering immune responses, likely related to the capacity of UV-B energy to affect antigen presentation in skin by interacting with epidermal Langerhans cells. Implications of this suppression in terms of altered susceptibility to cutaneous cancer or to infection remain to be defined (Bickers, 1998).

Chronic sleep loss including circadian disruption may also produce immunologic and endocrine effects on the wide range of body functions controlled by the'internal biological clock including body temperature, digestion, physical and mental performance, and endocrine and immune functions (Dinges et al, 1995). .Understanding the physiological significance of chronic fatigue and potential immunologic changes will require additional research. Indeed, the critical question is whether chronic fatigue and/ or chronic sleep loss compromises the health of the individual

The next phase of our epidemiological research will be to begin initial investigations into the incidence of melanoma and other disease outcomes in a group of airline pilots as related to the factors of short versus long haul operations, and overnight operations.

Currently, our research group is examining if chronic low-dose radiation exposure can be detected using biological markers; such as chromosomal changes in circulating white blood cells. The primary objective is to develop a better understanding of the potential biological hazards in airline pilots chronically exposed to low radiation doses. This would be the first North American study to investigate radiation-related biological markers in this professional group.

References available upon request.

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*Canadian Airlines International (Captain B737/200, on educational leave of absence), Director, Air Line Pilots Association: Flight Deck Occupational Exposure Research, Medical Student, Faculty of Medicine, University of Calgary.

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AN INVITATION TO SUBMIT ARTICLES

http://www.med.ucalgary.ca/oemweb

The Alberta Occupational Medicine Newsletter is looking for interesting and timely articles for publication. Articles generally follow one of several themes:

- the prevention, diagnosis, treatment, and rehabilitation of occupational illness or injury;
- educational opportunities and resources available to Alberta physicians;
- teaching and research activities of Alberta educational institutions relevant to occupational health and medicine;
- Alberta governmental policies and programs relating to occupational health, safety, and workers' compensation.

With thanks to the Workers' Compensation Board Alberta and the AMA Section of Occupational Medicine we are pleased to offer an honorarium of $250.00 to the author of a keynote article. We invite you to submit any case reports, original articles, and other informational items for the Newsletter. Articles should be no more than 3000 words in length, contain no more than two tables or diagrams, and may cite up to six key references. Please submit both a hard copy and a electronic version by email or a 3.5 inch disk. There are no strict formatting or style guidelines, and any significant editorial changes are subject to your approval prior to publication.

The Newsletter has been in circulation since 1983 and is published twice yearly. Articles from past issues are posted on our website at ***http://www.med.ucalgary.ca/oemweb***

COURSE ANNOUNCEMENT:

OCCUPATIONAL HEALTH I - MDSC 645.07 - Winter Session 2001

Department Of Community Health Sciences
University Of Calgary

INSTRUCTOR: Dr. Ken Corbet and Ms. Gene Shematek

DATES: January 10 through April 11, 2001

TIME: Wednesday evenings 1800 - 2030 hours

PLACE: Room G383 Heritage Medical Research Building

This graduate level course is intended for those new to the practice of occupational health, including physicians, nurses, other health-related practitioners, and professionals in engineering, management or law. It will link three conceptual models: the hazard control model (identification, evaluation, control), the medical model (absorption, effect, and disease), and the social model (impairment, disability, and handicap). Students will:

- gain an appreciation of the inter-disciplinary nature of occupational health.
- analyze basic problems relating to occupational hygiene, ergonomics, toxicology, medicine, rehabilitation, and occupational health programs.
- discuss issues in occupational health such as fitness to work, ethics and confidentiality, reproductive hazards, carcinogenesis, and drug testing.

There is no single text recommended for the course; key reference< for each class will be identified in monographs, journals, textbooks, and government publications. Evaluation will be by four take-home, short-essay and short-answer examinations.

This course may be taken for university credit or audit, either as part of a graduate program or as an unclassified student. Application for CME credits will be made to both the College of Family Practice of Canada and the Royal College of Physicians and Surgeons of Canada. For more information, please contact either Dr. Corbet (kcorbet@ucalgary.ca) or (403) 220-3362) or Crystal Elliot at (403) 220-4288.

SOUTHERN ALBERTA OCCUPATIONAL MEDICINE PAGE

http://www.med.ucalgary.ca/oemweb/

Web News

- Have a look at two updated Undergraduate modules:
  - Determinants of Health: Physical Environment
  - Occupational Musculoskeletal Health: Fitness for work and Return to work Planning
- The Occupational and Environmental Medical Association of Canada has launched its website, (www.oemac.org). OEMAC is the national specialty association for occupational medicine in Canada. ,Have a look at their membership information, current projects, and upcoming conferences.
- Interesting websites:
  - Ergonomic Guidelines for arranging a Computer Workstation: 10 tips for users ***(http://ergo.human.cornell.edu/ergoguide.html)***
  - 3M's Office Ergonomics Self-Help Site ***(www.mmm.com/cws/selfhelp/index. html)***
  - Medical Multimedia Group, provides some depth on the medical aspects of various musculoskeletal disorders. See A Patient's Guide to Cumulative Trauma Disorder

UPCOMING CONFERENCES

CANADA:

- **19th Annual General Meeting and Scientific Conference of the Occupational and Environmental Medical Association of Canada.**

  Title: "The Art and Science of Medical Assessment in the New Millenium".
  Presented in conjunction with The American Board of Independent Medical Examiners (ABIME) October 2-4, 2001

  September 29 - October 2, 2001
  Sheraton Halifax Hotel
  1919 Upper Water Street
  Halifax, Nova Scotia
  Canada
  Contact:
  Phone:1 (902) 456-3554
  Web:www.OEMAC2001.com

- **The Fifth International Symposium on Biological Monitoring in Occupational and Environmental Health**

  The Fifth International Symposium on Biological Monitoring in Occupational and Environmental Health will provide a forum for the exchange of ideas among colleagues in such high impact areas as analytical chemistry, epidemiology, molecular biology, occupational health and public health.

  September 19 - 21, 2001
  Banff, Alberta, Canada

  Contact:
  Office of Continuing Medical Education
  University of Calgary
  3330 Hospital Drive NW
  Calgary, Alberta T2N 4NI
  Canada
  Phone:1 (403) 220-7032
  Fax:1 (403) 270-2330
  E-mail:isbm@ucalgary.ca
  Web: http://www.cme.ucalgary.ca/isbm/

- **Advanced Diagnosis and Treatment for Neck and Back Pain 2000**

  Jointly sponsored by American Back society and Allegheny General Hospital, this meeting offers a comprehensive overview of the diagnosis and treatment of injuries and medical conditions affecting the cervical, thoracic, and lumbosacral regions of the spine. Industrial and occupational injuries will be discussed in great depth, and will include current issues that confront the healthcare provider.

  December 7 - 9, 200O
  Vancouver, British Columbia, Canada

  Contact:
  American Back Society
  2647 International Boulevard, Suite 401
  Oakland, California 94601, USA
  Phone:51 O-536-9929
  Fax:51 O-536-1 812
  E-mail:info@americanbacksoc.com

INTERNATIONAL:

- **"WorkCongress5" The International Congress on Work Injuries Prevention, Rehabilitation and Compensation**

  The four-day congress will include a major focus on "re-assessing structures", that is comparing the range of approaches around the world in work injuries prevention, rehabilitation and compensation. Other themes for the congress include health issues, labour market issues and vision for the future.

  March 14 - 20, 200l
  Melbourne and Adelaide, Australia

  Contact:
  Congress secretariat
  E-mail: secretariat@workcongress5.org
  Web: http://www.workcongress5.org/

For a more complete listing of conferences, check out our website at:
www.med.ucalgary.ca/oemweb