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Short Communication

Chromosomal damage in air crew members of international flights. A preliminary report*

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Abstract

Air crew members of international flights are exposed to ionizing radiations originated from the collision of cosmic particles with atoms of the atmosphere. The degree of exposure varies according to the altitude, latitude, and solar activity. The cytogenetical analysis showed a significant increase of dicentric chromosomes (14.5 ± 0.76 per 1,000 cells) in active air crew members as well as in retired air crew members (7.5 ± 0.59 per 1,000 cells) in relation to controls (0.5 ± 0.05 per 1,000 cells). In active members the frequency of ring chromosomes was also increased (2.0 ± 0.31 per 1,000 cells) but not found in retired crew members. These observations suggest a high degree of exposure to ionizing radiations of air crew personnel. Consequently, the cytogenetic follow-up of air crews chronically exposed to low radiation doses is an open field for further investigations.

INTRODUCTION

Air crew members of international flights are exposed to ionizing radiations (electrons, fast neutrons and protons) originated from the collision of cosmic particles with atoms of the atmosphere. The degree of exposure varies according to the altitude, latitude, and solar activity. Consequently, these air crew members, who cruise at altitudes higher than 30,000 feet on long haul flights are more exposed than, for example, air crew members of domestic flights (Bramlitt, 1985; Friedberg *et al.*, 1989, 1993; Bagshaw *et al.*, 1996). This type of exposure differs from that produced at ground level as a consequence of catastrophes or nuclear accidents such as Chernobyl or Goiânia, respectively, where the populations were exposed to high doses for short periods. In this case, air crew members are exposed to low doses for years.

The number of dicentric and ring chromosomes is considered as a biological dosimeter for radiation exposure (Hagmar *et al.*, 1998). However, most studies were carried out after acute exposures and few data are available about chronically exposed populations (Evans *et al.*, 1979; Schmitz-Feuerhake *et al.*, 1993, 1997). The analysis of chromosomal aberrations in air crew members has been reported by several authors (Scheid *et al.*, 1993; Heimers *et al.*, 1995; Romano *et al.*, 1997; Wolf *et al.*, 1999; Heimers, 2000). However, the results obtained showed some discrepancies. Whereas significant increases in chromosomal aberrations were found in air crew members of subsonic flights (Scheid *et al.*, 1993; Heimers *et al.*, 1995; Romano *et al.*, 1997), no differences were observed when the cytogenetic study was made on female cabin attendants compared to controls (Wolf *et al.*, 1999). On the other hand, high frequencies of chromosomal aberrations, mainly dicentric chromosomes, were found in Concorde pilots (Heimers, 2000) and astronauts (Obe *et al.*, 1997).

The aim of the present study was to analyze the frequencies of chromosomal aberrations in pilots and flight engineers of international flights as well as in retired pilots and flight engineers. The study was performed with members of the "Asociación de Pilotos de Líneas Aéreas" (Air Lines Pilots Association, APLA) from Argentina.

MATERIAL AND METHODS

Heparinized blood samples were obtained from 10 pilots and flight engineers of international flights, 10 retired pilots and flight engineers and 10 controls matched by age, selected among technical ground workers. Lymphocyte cultures were carried out with Ham F10 medium supplemented with 10% fetal bovine serum, phytohemagglutinin, and antibiotics (100 IU/ml penicillin and 100 µg/ml streptomycin) for 52 h. Metaphase spreads were stained with Giemsa. Coded slides were analyzed by one observer. A total of 200 metaphases were scored per donor.

RESULTS

Tables I, II and III show the frequencies of chromosomal aberrations found in active crew members, retired crew members, and controls. In active and retired crew members the frequencies of dicentric chromosomes were higher than that of controls (14.5 and 7.5 dicentric chromosomes per 1,000 cells, respectively, against 0.5 dicentric chromosomes per 1,000 cells in controls). In active crew members the frequency of ring chromosomes was also higher than that of controls (2.0 ring chromosomes per 1,000 cells versus 0). In addition, other types of aberrations such as despiralized chromosomes and telomeric associations were found. Despite the fact that the frequency of dicentric chromosomes was higher in active than in retired crew members, statistical analysis with the Mann-Whitney U-test showed that the differences were not significant (P = 0.3367).

DISCUSSION

The frequency of dicentric and ring chromosomes found in active crew members was 29-fold higher than that of controls and 10-fold higher than that of the historical controls of our laboratory and the frequency reported for a larger number of individuals. Even though the frequency of dicentric chromosomes was lower in retired air crew members than in active crew members, no significant differences were found between these values.

The amount of chromosomal damage found in Argentinian pilots and flight engineers was higher than those reported in previous papers (Scheid *et al.*, 1993; Heimers *et al.*, 1995; Romano *et al.*, 1997; Wolf *et al.*, 1999). Although the sample size is small, results can be considered as evidence of a high degree of exposure of air crews to ionizing radiation. This high exposure level could be from several causes: 1) most of the international flights from

Table I - Frequency of chromosomal aberrations found in active air crew members. Standard error of the mean is indicated in parentheses. A total of 200 metaphases per donor were analyzed.

Donor No.	Abnormal metaphases[1] (%)	Chromosomal aberrations per 100 cells				
		AL[2]	B'[3]	B"[4]	Dic[5]	Rin[6]
1	5.0	3.0 (1.20)	0	3.0 (1.20)	3.0 (1.20)	0
2	1.0	2.0 (0.98)	0	0.5 (0.49)	0	0.5 (0.49)
3	6.0	0.5 (0.49)	1.5 (0.85)	3.5 (1.29)	2.5 (1.10)	0
4	6.5	5.5 (1.61)	4.5 (1.46)	1.5 (0.85)	0	0
6	6.0	3.0 (1.20)	1.0 (0.70)	4.5 (1.46)	0.5 (0.49)	0
9	10.0	14.0 (2.45)	4.0 (1.38)	4.5 (1.46)	2.5 (1.10)	0
10	7.5	7.5 (1.86)	1.5 (0.85)	0	2.0 (0.98)	0.5 (0.49)
13	12.0	10.0 (2.12)	7.5 (1.86)	5.5 (1.61)	1.0 (0.70)	0
16	7.5	4.5 (1.46)	1.0 (0.70)	6.5 (1.74)	0	1.0 (0.70)
67	10.5	7.5 (1.86)	3.0 (1.20)	3.5 (1.29)	3.0 (1.20)	0

[1]Metaphase with at least one chromosomal aberration. Metaphases exhibiting only achromatic lesions (gaps) were not considered as abnormal; [2]achromatic lesions (gaps); [3]monochromatid breaks; [4]isochromatid breaks plus acentric fragments; [5]dicentric chromosomes, and [6]ring chromosomes.

Table II - Frequency of chromosomal aberrations found in retired air crew members. Standard error of the mean is indicated in parentheses. A total of 200 metaphases per donor were analyzed.

Donor No.	Abnormal metaphases[1] (%)	Chromosomal aberrations per 100 cells				
		AL[2]	B'[3]	B"[4]	Dic[5]	Rin[6]
51	2.5	5.5 (1.61)	3.0 (1.20)	2.5 (1.10)	0	0
52	6.0	11.5 (2.25)	2.0 (0.98)	4.0 (1.38)	0.5 (0.49)	0
54	6.0	16.5 (2.62)	2.5 (1.10)	2.5 (1.10)	0.5 (0.49)	0
55	5.5	8.0 (1.91)	2.0 (0.98)	3.0 (1.20)	0.5 (0.49)	0
56	7.5	9.0 (2.02)	2.5 (1.10)	3.5 (1.29)	1.5 (0.85)	0
57	8.0	7.0 (1.80)	2.5 (1.10)	2.0 (0.98)	1.0 (0.70)	0
58	11.0	15.5 (2.55)	4.0 (1.38)	5.0 (1.54)	1.0 (0.70)	0
59	3.0	3.5 (1.29)	0	1.5 (0.85)	1.5 (0.85)	0
61	4.0	5.0 (1.54)	1.0 (0.70)	2.0 (0.98)	0	0
64	12.0	14.5 (2.49)	4.0 (1.38)	8.5 (1.97)	1.0 (0.70)	0

[1]Metaphase with at least one chromosomal aberration. Metaphases exhibiting only achromatic lesions (gaps) were not considered as abnormal; [2]achromatic lesions (gaps); [3]monochromatid breaks; [4]isochromatid breaks plus acentric fragments; [5]dicentric chromosomes, and [6]ring chromosomes.

Table III - Frequency of chromosomal aberrations found in controls. Standard error of the mean is indicated in parentheses. A total of 200 metaphases per donor were analyzed.

Donor No.	Abnormal metaphases[1] (%)	Chromosomal aberrations per 100 cells				
		AL[2]	B'[3]	B''[4]	Dic[5]	Rin[6]
100	2.0	0.5 (0.49)	0	2.0 (0.98)	0	0
103	3.5	2.0 (0.98)	0.5 (0.49)	3.0 (1.20)	0	0
104	2.0	0.5 (0.49)	0.5 (0.49)	1.0 (0.70)	0	0
105	4.5	3.5 (1.29)	1.0 (0.70)	1.5 (0.85)	0.5 (0.49)	0
106	3.0	6.0 (1.67)	1.0 (0.70)	2.0 (0.98)	0	0
107	3.5	7.5 (1.86)	2.0 (0.98)	1.5 (0.85)	0	0
109	2.5	3.5 (1.29)	1.0 (0.70)	1.0 (0.70)	0	0
110	1.5	2.5 (1.10)	0	1.5 (0.85)	0	0
111	3.0	3.5 (1.29)	0.5 (0.49)	2.5 (1.10)	0	0
114	4.5	4.0 (1.38)	1.5 (0.85)	3.0 (1.20)	0	0

[1]Metaphase with at least one chromosomal aberration. Metaphases exhibiting only achromatic lesions (gaps) were not considered as abnormal; [2]achromatic lesions (gaps); [3]monochromatid breaks; [4]isochromatid breaks plus acentric fragments; [5]dicentric chromosomes, and [6]ring chromosomes.

Argentina are transequatorial, with long hauls at high altitudes; 2) most of the pilots and flight engineers studied are routine crew members of the transpolar flight Buenos Aires-Auckland (New Zealand).

An interesting finding is the persistence of exchange type aberrations in retired air crew members, even after 10 years. In cytogenetic follow-up studies carried out six years after populations were accidentally exposed in Goiânia, Brasil, a rapid decrease in the frequencies of dicentric and ring chromosomes in the most exposed group (doses higher than 1 Gy) was found. In individuals receiving less than 1 Gy the disappearance of aberrations was slower. In the first case, the estimated average half life of dicentric elimination was 110 days for the initital period after exposure (until 470 days). In the second one, the half life was 160 days during the period of 470 days (Ramalho *et al.*, 1995). Consequently, the cytogenetic follow-up of air crews chronically exposed to low radiation doses, including cabin attendants, is an open field for further research. It has been demonstrated that the increase of exchange-type aberrations is an indication of cancer risk. In this study, this fact is supported by data about mortality of pilots obtained from the "Asociación de Pilotos de Líneas Aéreas" (APLA).

RESUMO

Tripulantes de vôos internacionais estão expostos a radiações ionizantes originadas da colisão de partículas cósmicas com átomos da atmosfera. O grau de exposição varia de acordo com a altitude, latitude e a atividade solar. A análise citogenética mostrou um aumento significante no número de cromossomos dicêntricos (14,5 ± 0,76 por 1000 células) em membros ativos da tripulação, assim como em tripulantes aposentados (7,5 ± 0,59 por 1000 células), em relação a controles (0,5 ± 0,05 por 1000 células). Em tripulantes em atividade a freqüência de cromossomos em anel também aumentou (2,0 ± 0,31 por 1000 células), mas isso não ocorreu em tripulantes aposentados. Estas observações sugerem um alto grau de exposição do pessoal de bordo a radiações ionizantes. Conseqüentemente, o acompanhamento citogenético de tripulantes de aviões cronicamente expostos a baixas doses de radiação é um campo aberto para futuras investigações.

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