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Increased Cancer Risk Associated with Radiation in Aerospace

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Abstract

There is increased risk of malignancies in association with radiation exposure in aerospace due to UV, cosmic radiations and due to fuels. Radiation could be ionizing and non ionizing [1]. Predominantly skin malignancies are caused by non-ionizing ultraviolet radiation and UV radiation which causes DNA damage, dimerization and defective repair [2]. Leukemia occurs due to ionizing radiation. There are oncogenes implicated in human skin cancers like ras oncogenes.

Oncogenes display a positive effect on transformation, whereas tumor suppressor genes have an essentially negative effect, blocking transformation. Ionizing irradiation induces alterations within the tumor microenvironment. Radiation delivered to the tumor bed can prompt phenotypic changes in both normal stromal and cancer cells, leading to molecular and physiological alterations within the tumor microenvironment. These environmental modulations directly influence the degree of immunogenicity of the tumor microenvironment and may ultimately affect tumor responsiveness to cancer immunotherapies.

Keywords: Radiation; Melanoma; Skin cancer; Breast cancer

Introduction

Exposure of long duration to ionizing radiation causes a variety of neoplasms. The most common cases known to occur are malignant melanomas in skin, skin cancers, leukemias and breast carcinomas [1,2]. The Federal Aviation Administration (FAA) has recommended that aircrew members be exposed to no more than 20mSv per year for a 5 years average, with no more than 50mSv in a single year [3,4]. Radiation alters the molecular structure by causing ionization and energizing the molecule. Less energetic radiation, such as visible light, only causes excitation, not ionization, which is usually dissipated as heat with relatively little chemical damage [5-8]. Ultraviolet light is not entirely non-ionizing, but produces some ionization and chemical damage. Effects of ultraviolet radiation and ionizing radiation are similar in the causation of cancer and penetrating ionizing radiation hits the molecules randomly [9-11]. Radiation causes production of free radicals by breaking the molecules and causing damage to the chromosomes and genetic rearrangements, translocations and mutations. In this way irreversible cellular damage and chromosomal derangements occur. Major damage normally results in the cell dying or being unable to reproduce with acute effects but these cells cannot cause cancer. The cells which are proliferating and in which the tumor suppressor genes are damaged, they prone to become cancerous. The latest research suggests that mutagenic events do not occur immediately after irradiation. There is phenomenon of microsatellite instability and mismatch repair in the genes which causes mutations in generations and leads to genetic predispositions to cancer. The cell will then progress through multiple stages of neoplastic transformation that may culminate into a tumor after years of incubation. Oncogenesis is due to changes in morphology of cell, uncontrolled proliferation of cells and cellular adaptions to cancer. Prolonged exposure to ultraviolet radiation from the sun can lead to melanoma and other skin cancers which are now supposed to be very common malignancies.

Discussion

Zeeb et al. [11] did not find any increased cancer mortality with radiation. The increased risk of specific malignancies has been evident predominantly in populations involved in frequent air travel such as pilots and aircrew.

A cohort involving 10211 pilots from Nordic countries (Iceland, Sweden, Denmark, Norway and Finland) was conducted in 2003. In this study, it was found that there was increased incidence of malignant skin melanoma in pilots who flew more than 5000 block hours (hours per annum). Pukkala et al. [12] found association of melanoma with radiation exposure.

Nicholas et al. [13] identified chromosomal aberrations in peripheral lymphocytes in the blood samples of male, non-smoker pilots based in Toronto. Fluorescent in situ Hybridization (FISH) was done and the mean aberration frequency was 3 times higher in the pilot group in contrast to the non-airline control group. Horstmann et al. [14], who concluded that space radiation does not induce a significant increase of intra-chromosomal changes after conducting FISH studies on 11 astronauts' blood lymphocytes. However the group failed to address any possibility of interchromosomal changes. Gundestrup et al. [15] have shown deletion of the long arm of chromosome 7 in aircrew members strongly associated with AML. Gundestrup et al. [16] also established causation of acute myeloid leukemia due to radiotherapy.

Breast cancer is predominantly more common in females than males; the vast majority of studies investigating the effects of ionizing radiation involve female cabin attendants and pilots. Meta-analyses have indeed shown increased incidence of breast cancer in the former. An example was that conducted by Buja et al. [17]. Bayesian hierarchal models were applied to the results of 7 published studies after standardized incidence ratios (SIRs) were estimated. Likewise similar results were portrayed by Tokomaru et al. [18]. According to Barr et al. [19], it is insufficient to draw a statistically significant conclusion pertaining to the risk of breast cancer in such a female population.

Conclusion

Age, ethnicity (genetic factors and predispositions), gender and other confounding factors facilitate carcinogenesis independent of radiation exposure. Breast cancer etiology apart from genetics, depends on numerous other factors e.g. nulliparity, smoking etc. The multivariate causes in addition to radiation exposure contribute towards causation of cancer.

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