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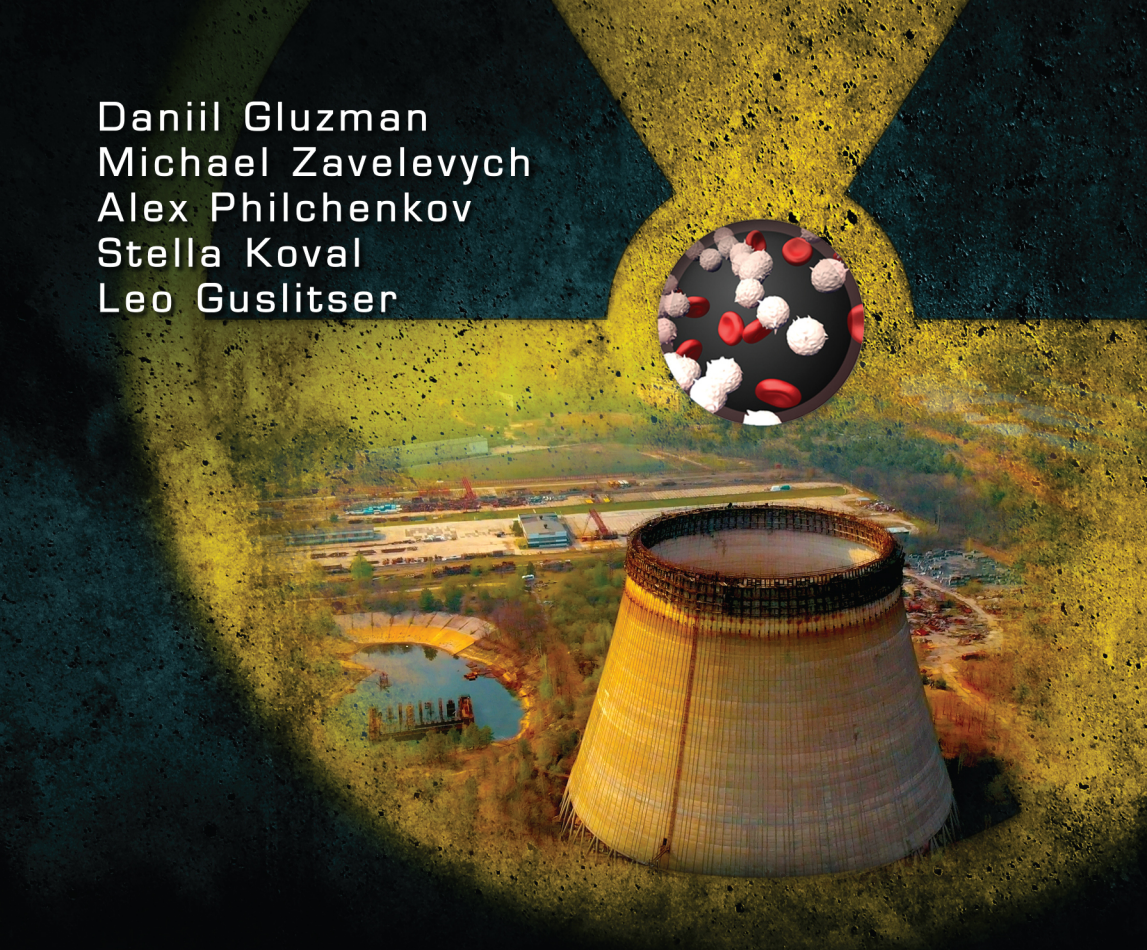

Leukemia. Radiation. Chornobyl

(Oncohematological Consequences of the Chornobyl Catastrophe)

Nuclear Materials and Disaster Research

NOVA

This work carried out by Professor Daniil F. Gluzman and his colleagues from the R.E. Kavetsky Institute of Experimental Pathology, Oncology and Radiobiology of Kyiv, National Academy of Sciences of Ukraine on the consequences of the Chornobyl disaster in 1986 on the incidence of hematologic malignancies in the most affected regions in Ukraine should be praised. A difficult endeavor given the scarcity of local registries for different diseases. The authors for the first time report a trend towards an increase in some forms of leukemia, in particular acute myeloid leukemia (AML) and chronic lymphocytic leukemia (CLL) and, possibly, also of myelodysplastic syndromes following the Chornobyl tragedy. While the data on AML were expected, the evidence of an increase in CLL cases is probably a surprise and the effect of long-lived radionuclide contamination on chronic B-cell malignancies deserves further investigation. The book contains also a detailed description on the available literature data. From the survivors of the atomic bombs on Hiroshima and Nagasaki in 1945, to nuclear weapon tests and radiation accidents, and their possible association with malignant diseases. Finally, a chapter is dedicated to biomarkers of radiation-associated leukemogenesis. In essence a comprehensive book on the potential consequences of nuclear leaks that ties together literature data, biomarkers and the first evidence of the consequences of the Chornobyl explosion on the occurrence of hematologic malignancies. A book that in my opinion should be made broadly available to the medical community, but also to the general public. Global awareness and information have become a crucial part of our existence and wellbeing today and more so tomorrow.

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To the memory of Borys Paton (1918–2020),
the outstanding scientist, Academician,
President of the National Academy of Sciences of Ukraine

CONTENTS

PREFACE

The nuclear accident that happened on April 26, 1986 in Chornobyl nuclear power station located 130 km north from Kyiv, the capital of Ukraine, became the worst radiation disaster in the history of the nuclear industry. A total of about 14 EBq (14×10^{18} Bq) of radioactivity was released including radionuclides important from the radiobiological point of view. In particular, an area of more than 200 000 km^2 in Europe was contaminated with ^{137}Cs, of which 71% was in the most affected countries – Republic of Belarus, the Russian Federation and Ukraine. Millions of people inhabiting the areas contaminated with radionuclides have been exposed to the low doses of ionizing radiation for a long time due to the residual contamination of soil and ecosystems with long-lived radionuclides such as ^{137}Cs, ^{90}Sr, which predominantly contribute to the population dose as well as transuranic nuclides.

Due to potential health danger, more than 350 thousand residents of the suffered regions were evacuated and relocated in 1986–1991. Nevertheless, more than 5 million adults and children up to present inhabit the territories with the level of contamination of 1 Ci/m^2 and more. These groups are at the increased risk of the stochastic consequences of protracted exposure to low dose radiation. Moreover, about 600 thousand people have been exposed to radiation during the recovery works in Chornobyl nuclear power station in 1986–1987.

The difference in the association of specific forms of leukemia with the effects of ionizing radiation seems to be determined by the differences in the radiation type, the dose and dose rate in single, fractionated or protracted exposure as well as the patterns of the distribution of the incorporated radionuclides in various organs and tissues of the body.

Hematopoietic and lymphoid tissues are the most radiosensitive in the body. A lot of evidence confirms that the low doses of ionizing radiation may be the causative factor of the different types of leukemia. The hematopoietic stem and progenitor cells residing in the bone marrow are the major cells at risk of leukemogenic conversion following long-term radiation exposure. These target cells for radiation-associated leukemia has been well characterized and incorporated into the modern schemes of hematopoiesis. The increase in the risk of leukemia associated with the exposure to the low doses of ionizing radiation runs in parallel with the emergence of the recurrent genetic abnormalities and mutations in the transformed cells as well as alterations in hematopoietic stem cell microenvironment.

The understanding of the precise mechanisms of leukemogenesis in the setting of the low dose radiation exposure remains a challenging issue. The priorities in the key research of the basic mechanisms of radiation-associated leukemogenesis should rely on the insight into the precise nature of the target cells, the role of DNA damage and mutations, the contribution of the epigenetic modifications, the effects of the components of microenvironment.

The risk of childhood leukemia associated with radiation exposure deserved particular attention. As to the hematological malignancies associated with radiation exposure in the adults, the risks of several forms of leukemia such as chronic lymphocytic leukemia, myeloid neoplasms (polycythemia vera, primary myelofibrosis, essential thrombocytemia) were underestimated and even overlooked. The association between radiation and preleukemias, especially myelodysplastic syndromes was not covered sufficiently as well.

The further studies in the attempts to prove the radiogenic nature of the specified forms of hematological malignancies require the exact

reconstruction of the individual radiation doses based on the data of EPOR spectrometry of the dental enamel, the analysis of the stable aberrations in the chromosomes of the peripheral blood lymphocytes and other assays. Unfortunately, such data in post-Chornobyl period are scarce.

The authors of this monograph, the researchers from Oncohematology Department of the R.E. Kavetsky Institute of Experimental Pathology, Oncology and Radiobiology, the NAS of Ukraine are engaged for many years in the study of the tumors of hematopoietic and lymphoid tissues in the adults and children of 20 regions of Ukraine and Kyiv city and Chornobyl clean-up workers. The Reference Laboratory operating on the basis of the Department provides for the refined diagnosis of hematological malignancies. The activity of the Reference Laboratory covers more than one third of all the patients diagnosed with hematological malignancies in Ukraine. The major objective of the studies is to delineate the probable changes in the patterns of the oncohematological diseases in the regions of Ukraine that were contaminated with radionuclides including the analysis of the relative contribution of various forms and variants of such diseases in the overall structure of the tumors of hematopoietic and lymphoid tissues in Ukraine in post-Chornobyl era.

The formation of the computerized database of the patients and systematization of the archives of the specimens of the patients having been diagnosed in the Reference Laboratory for several decades could be the basis for the future comprehensive molecular epidemiological studies of the radiation-associated leukemia.

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