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The Science Behind A Nuclear Bomb



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HUMAN

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ABSTRACT

Exposure to ionizing radiation in general terms have long been linked to leukemias and many solid cancers. The effect of ionizing radiation released by a nuclear bomb, in particular, has long since been inducing much wider range and more multi-faceted research lines in the science of medicine as it has a multitude of interacting parameters to consider and evaluate in terms of the exposures mode, dose threshold, duration and immediate and long term physical and chemical impact. In this paper, we will be probing into the full implications related to the effects of ionizing radiation released by a nuclear bomb from a wider prospective.



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INTRODUCTION

On August 6, 1945, the United States Army Air Forces (USAAF) detonated a uranium gun-type fission bomb nicknamed "Little Boy" over the Japanese city of Hiroshima. (1)

On August 9, the USAAF detonated a plutonium implosion-type fission bomb nicknamed "Fat Man" over the Japanese city of Nagasaki. These bombings caused injuries that resulted in the deaths of approximately 200,000 civilians.(2) The U.S. Environmental Protection Agency (EPA) toxic exposure guidance recognizes an enhanced early lifecycle (3) The countries known to have nuclear weapons are the United States, the Soviet Union (Russia), the United Kingdom, France, China, India, Pakistan, and North Korea. Germany, Italy, Turkey, Belgium, the Netherlands, and Belarus are nuclear weapons sharing states. (4) South Africa is the only country to have independently developed and then renounced and dismantled its nuclear weapons. (5)

The Indian Army was involved in the test preparations at the Pokhran Test Range in Rajasthan. The project was code named *Operation Smiling Buddha* designation: *Pokhran-I*) while as per the United States military intelligence, the operation was named as Happy Krishna. (6) In August 2022, the UN Secretary-General António Guterres warned that the world is now in “a time of nuclear danger not seen since the height of the Cold War.”(7) Exposure to ionizing radiation is a well-established risk factor for female breast cancer, particularly when exposure occurs at a young age(8) Current nuclear arms control and nonproliferation efforts are inadequate to protect the world’s population against the threat of nuclear war by design, error, or miscalculation..”(9) Progress has been disappointingly slow and the most recent NPT review conference in 2022 ended without an agreed statement.(10)

There are many examples of near disasters that have exposed the risks of depending on nuclear deterrence for the indefinite future.(11) Male breast cancer is rare and, consequently, much less is known about its etiology and radiation effect. (12,13)

From 1945 to 1964, the United States, the Union of Soviet Socialist Republics (USSR), the United Kingdom, France, and China successively became nuclear-armed countries (14) The danger of use of nuclear weapons is greater than ever before due to proliferation of nuclear weapons, terrorism, and political instabilities (15) Russia's recent invasion of Ukraine has heightened the nuclear war risks concerned about nuclear weapons (16) An initial nuclear

radiation level drops quickly based on the distance from a fireball; less than 1 roentgen reaches 8 km from ground zero (17) The roentgen is a legacy unit to measure radiation exposure by a person over a period of time. Residual radiation results from neutron-caused radioactive materials in the environment as well as fission products in fallout (18) An increase in the incidence of radiation-caused cancer may be noted many years after exposure (19) Bombing occurs in a city center, rescue services there will suffer severe structural damage and may fail to work. (20)

History

Physicist J. Oppenheimer and Army Lt General Leslie Groves produced the world's first atomic bomb. USA, developed the first nuclear weapon during world war 11 in cooperation with UK and Canada. During 1938, Otto Han Radiation chemist and Fritz Strassmann, while bombarding elements with neutrons in their Berlin laboratory, made their unexpected discovery. Dr. Chidambaram, in 1969 was used plutonium Dr. V S Ramamurthy, designed the bomb core Development of detonation system began in 1970 with Dr Pranab R. Dastidar.

India is the owner of nuclear weapons and formerly developed chemical weapons.

India's Nuclear capabilities

India's nuclear capabilities and ballistic missiles including the Agni-1, the Agni-2, and the Agni-3 have the potential to deliver nuclear warheads. India has several aircraft that can be used as delivery vehicles including Jaguar, the mirage-2000, and the Su-30. The nuclear submarine INS aircraft gives India the maritime strike capacity.

Chemistry of the nuclear weapons

India possesses nuclear weapons and previously developed chemical weapons. Protons and neutrons make up a nucleus, which is the foundation of nuclear science. Fission and fusion involves the dispersal and combination of elemental nucleus and isotopes, and part of nuclear science is to understand the process behind this phenomenon. Adding up the individual masses of each of these subatomic particles of any given element will always give you a greater mass than the mass of the nucleus as a whole. The missing idea in this observation is the concept called nuclear binding energy. It is the energy required to keep the protons and

neutrons of a nucleus intact, and the energy that is released during a nuclear fission or fusion is nuclear power.

Biochemical effects of radiation on the internal organs:

It is learnt that radiations whether they are of smaller amount or larger amount will definitely contribute to certain harmful effects irrespective of their sources either natural radiation or man-made radiations. Radiation affects the living by the process known as ionization. Through the process of ionization it affects the body in an order of hierarchy. It first affects the atom further effects the molecule, cell, tissue, organs and the entire body. Radiation has direct effect- damage the DNA structure. Indirect effect is through radiation when passed through water molecule of cell causes breakdown of bond to form Hydrogen and Hydroxyls further forming toxic compounds like hydrogen peroxide (H_2O_2) converting water. H_2O_2 is a toxic product causes cell destruction. Damage caused to cell is based upon the nature of cell and its frequency of reproducibility. Different type of cells has different sensitivity towards radiation. For instant muscle and nerve cells has last sensitivity towards radiation as they are the slowest to regenerate. On the other hand Lymphocytes regenerates constantly hence are more sensitive for radiation. Gastrointestinal and reproductive cells regenerate very slowly so are less sensitive. Nature has gifted the cells to get repaired from damage but all the damages caused are not reversible. Not all radiations are reversible; it depends upon the severity of the damage caused to cell. If severity of damage is serious the cell dies, if moderate the cell would be able regenerate but may lack one or more critical components as results of this they may die. Certain cells will not die rather they may undergo mutations further get converted to benign or tumor cell. Radiation effects are acute and chronic based on the doses. Acute effect is the result of high dose and chronic is due to low dose of radiation. It is understood that radiation does have toxic effect on the complete body irrespective of its dose when high or low. Radiation causes genetic, somatic, in-utero effects.

Genetic effects: Radiation causes mutation of egg and sperm cells. These mutated cells are passed to the off-springs caused toxic imprinting effects on the newborn.

Somatic effects: as it is known that radiation is a carcinogenic physical component. It has its effect on almost all the internal organs and is occupational specific. Uranium miners suffer with lung cancer, therapeutic related breast cancer and thyroid cancer, bone cancer is observed in painters.

In-utero Effects: may cause developmental abnormalities, growth retardation, lead to intrauterine death and childhood cancers. The effect is specific to time or the fetal developmental stage at which the fetus gets exposed to radiation. For instance 0-1 week after conception may lead to pre-implantation, 2-7 weeks may cause organogenesis and 8 - 40 weeks known as fetal stage may lead to all the above mentioned complications, from developmental abnormalities to death of the newborn.

Radiation Dermatitis

Great progress is being made in understanding the mechanisms underlying this form of radiation damage, and in developing diagnostic and therapeutic modalities for management of skin and deeper tissue injuries. Radiation dermatitis is one of the main side effects of radiation exposure. (21)

Acute radiation dermatitis occurs within 90 days of exposure to ionizing radiation, while the chronic form may develop months or years after treatment (22). The first dose of radiation causes acute damage and destruction of the basal keratinocytes; with the persistence of exposure to ionizing radiation, the process continues, thus determining structural and histological changes in the skin and connective tissue (23) Radiation-induced damage is mediated by free radicals that damage DNA, proteins, lipids, and carbohydrates. Impairment of stem and endothelial cells, recruitment of inflammatory cells, apoptosis, and necrosis of epidermal cells follow from acute damage. (24,25)

Clinical manifestations of acute radiation dermatitis vary with the amount of radiation exposure and range from erythema to desquamation and ulceration. (26) Mild erythema caused by dilation of the capillaries may occur within hours of the patient's exposure to radiation; erythema can be associated with edema, itching, and burning. In addition, hair follicles and sebaceous glands can be affected, resulting in skin xerosis and hair loss. (27) Skin manifestations are generally evident 1–2 weeks after completion of radiotherapy and resolve 2 to 4 weeks after the end of treatment. (28) The main cytokines involved in inflammatory and fibrosis-stimulating processes are tumor necrosis factor-alpha (TNF-alpha), tumor growth factor-beta (TGF-beta), interleukins 6 and 1 (IL-6 and IL-1), connective tissue growth factor and platelet-derived growth factor (PDGF). (29)

Radiation-Induced Cerebro-Ophthalmic Effects in Humans

Research is still needed in the following areas: a comprehensive evaluation of the overall effects of IR on the eye, dosimetry methodology and dose-sparing optimization techniques, additional high-quality epidemiology studies and a basic understanding of the mechanisms leading to different eye disorders and to their interactions with brain processes. (30)

Devastating effects of Nuclear weapons

The most immediate effect of a nuclear explosion is an intense burst of nuclear radiation, primarily gamma rays and neutrons. This **direct radiation** is produced in the weapon's nuclear reactions themselves, and lasts well under a second. Lethal direct radiation extends nearly a mile from a 10-kiloton explosion. With most weapons, though, direct radiation is of little significance because other lethal effects generally encompass greater distances. An important exception is the enhanced-radiation weapon, or neutron bomb, which maximizes direct radiation and minimizes other destructive effects.

The consequence of Radiation

High-energy Ionizing radiation has the power to release electrons from atoms, which can disrupt covalent bonds in DNA. This process occurs when an electron from the DNA molecule or a nearby molecule impacts and breaks the DNA molecule directly; this is known as direct action. About 0.0000000000000001 of a second passes during this initial ionization. However, indirect action is thought to be responsible for almost two thirds of the damage produced by x-rays nowadays. This happens when the freed electron impacts a common water molecule rather than the DNA directly. As a result, the water molecule becomes ionized and eventually produces a free radical. In an attempt to return the electrons to their stable state, a free radical reacts violently with other molecules. A free radical's drift can last up to 10,000,000,000 times longer than the time it took for the initial ionization—roughly 0.00001 of a second—which increases the likelihood that it would damage the important DNA molecule.

Reactive oxygen species (ROS) production, which oxidizes proteins and lipids and causes several damages to DNA, including the creation of a basic sites and single strand breaks (SSB), are secondary effects. All of these modifications work together to cause mitotic failure and cell death. Cells that divide slowly and are quiescent, such as those that make up the

nervous system, are less radiosensitive than high-proliferation cells, which include skin, bone marrow, and the epithelial cells of the gastrointestinal tract.

Exposure to very high levels of radiation, such as being close to an atomic blast, can cause acute health effects such as skin burns and acute radiation syndrome ("radiation sickness").

It can also result in long-term health effects such as cancer and cardiovascular disease.

Bringing nuclear risks back into popular imagination

Little Boy' was dropped on Hiroshima on August 6, 1945 at 0815 hours. This was followed three days later by the dropping of 'Fat Man' on Nagasaki, at 1101 hours. The two nuclear bombs vaporized around 150,000 people who were going about their morning business; 130,000 others succumbed to burns, radiation sickness, and other ailments that the collapsed health system could not treat. Few, then, understood why their skin erupted wounds that would not heal, hair fell off in clumps, and stomach churned with pain and nausea. Several *hibakusha*, or survivors of the atomic bombings, have recounted how an ordinary day turned into one where they wished they too had died in that instant flash. The purpose of recalling these horrors from 75 years ago is to ensure that nuclear armed states do not forget the real nature of nuclear weapons. Human memory is short and often preoccupied with the immediate. Currently, the socio-economic-health emergency posed by COVID-19 and the growing geopolitical tensions between major powers owing to their abrasive behaviour seem to be consuming us all. But nuclear risks are lurking just below the surface, and they are growing.

Rates of childhood cancer and mortality seem to be increasing. Birth defects and genetic abnormalities, even in children born years after the tests, are common. There are many children who have never learned to walk or speak. High rates of breast cancer have also been reported. Unfortunately, this is to be expected: ionizing radiation, which is released in a nuclear explosion, disproportionately affects rapidly growing and dividing cells, which are generally found in women and children. Despite nuclear weapons testing's obvious health effects, the Indian government only provided compensation for land damaged immediately after the test. Multiple small-scale studies have confirmed that there is a dangerous health phenomenon near Pokhran. But there has been no government-accepted investigation and the villages must rely on their own estimates of cancer deaths and other illnesses. With no formal

study, it is hard for residents to demand assistance because they cannot explicitly point to the nuclear weapons tests as the cause.

Nuclear blasts are catastrophic

The detonation of a nuclear bomb is an event of catastrophic proportions, unmatched in its immediate and long-term destructive capabilities. The energy unleashed in the explosion and the aftermath that follows have been subjects of intense study and concern due to their profound impacts on the environment, human health, and global politics. This article examines the sequence of events during a nuclear explosion, the ensuing aftermath, and the historical context of nuclear weapons development, providing a comprehensive overview of the subject.

Radiation injury Deaths

In situations of nuclear terrorism or warfare hundreds of radioactive bodies were encountered which is unpreventable necessary precautions are must until the deceased were disposed of safely without endangering the alive population with acute and chronic pathological diseases.

Tag attached to body labeling 'Radioactive'

Radiation protection precautions in the Morgue

1. This is an appropriate place for the "one person at the table at a time" rule.
2. Do not touch the shrapnel with the hands.
3. Place a specimen jar in a bucket.
4. Remove the shrapnel with forceps and place it in the specimen jar.
5. Place the bucket 30 feet or more from the work area.
6. After the forensic examination and victim identification process is complete decontaminate the decedent.
7. This could be done in the final examination area, or the decedent could be moved to secondary decontamination area.

8. Surgically remove any shrapnel. If the decedent is still contaminated consider the contaminant internal contamination.

9. Tag the decedent with the dose rate, distance of the probe, date, and time; and release the decedent to the funeral home.

Autopsy

An autopsy normally entails extensive handling of internal organs by gloved hands. Do not perform an autopsy if there is internal contamination, unless it is absolutely necessary.

Special precautions

Autopsy team should include a Radiation expert from Hospital Nuclear medicine Department.

Plastic backed paper placed around Autopsy table on the floor so that radioactive fluids or tissues spilled out cleaned with wet mop cloth with a long handle and the cloth stored till complete decay occurs. If clothes of dead body are radioactive measure the radioactivity, record it in PME Report, clean them with soap and water and store till complete decay occurs.

Autopsy surgeon must know the dose if given and the residual radioactivity in the body.

Procedures for the handling of radioactive bodies in the mortuary

Exposure of individuals to radiation emitted by therapeutic radioactive materials retained in or on a corpse can be reduced by adopting the following precautions:

- Remove the radioactive materials as soon as safely possible;
- Work expeditiously to reduce the time of exposure;
- Work at a distance from the radioactive material rather than working unnecessarily close to it;

The RSO must be consulted to perform a risk assessment on the radiation-related problems likely to be met in performing an autopsy or disposing of the body.

Autopsy – Procedure

Most radioactive fluids and organs like Thyroid gland are removed and placed in covered glass jars.

Radiation experts examine them for radioactivity and advice whether these are safe for dissection or not; excessively radioactive organs are handled minimally. Radioactive iodine concentrates in the Thyroid gland & Urinary bladder. So, dilute the bladder content and drain off via catheter directly to the sewer.

CONCLUSION-

In the 50's nuclear weapons testing took place above ground and the characteristic mushroom cloud became the visible symbol of the nuclear age. India then took the lead in calling for an end to all nuclear weapon testing as the first step for ending the nuclear arms race.

Even if you escape from the immediate effects of radiation from the expulsion of a nuclear bomb, we cannot escape from the clutches of long-term ill effects of radiation which will cost human life for generations to come.

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