Medicine in the current nuclear age

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The purpose of this article is to introduce the medical community to the alternatives of global nuclear catastrophe and to the ultimate benefits to mankind of the peaceful use of nuclear energy.

The apparent end of the cold war did not bring any significant changes in the development and improvement of the nuclear arsenal either in the western world or the Russian Republic. In addition to the previous few members of the nuclear club, there has been an increasing number of the countries either capable of building or already in the possession of nuclear weapons as well as arsenal of ballistic missiles capable of delivering the warheads in the scenarios of strategic confrontation. The attempts of presenting to the public a drastic reduction of nuclear warheads applies in general to the reduction of the obsolete and outdated arsenal, whereas the multihead thermonuclear arsenal development has continued an unabated speed of production with exceedingly more sophisticated delivery systems, speed of response and improved accuracy in both strategic and tactical scenarios.

This paper addresses the projected physical, environmental, social, economic, psychological and medical consequences of nuclear war and accidents in nuclear industry, as well as ecological consequences of the still unresolved problem of high level nuclear waste. It also raises the questions about the feasibility of a limited nuclear war, the level of civil defense preparedness in the United States and the prospects for survival and recovery in the aftermath of a nuclear confrontation or large scale nuclear industry accidents. The important aspect of the paper addresses the issue of a plausibility of nuclear terrorism, physical security of nuclear civilian and military facilities and materials, uncontrolled building of nuclear weapons and international cooperation in containing the threat of the global dimension of nuclear terrorism.

Key words: current nuclear age, medicine

PHYSICAL EFECTS NUCLEAR WEAPONS

An explosion of a one megaton bomb releases energy equal to one million tons of TNT. This energy release creates blast, thermal radiation, and radioactive fallout. When a one megaton bomb is detonated, photons are within emitted one millionth of a second. Most of these X-rays are absorbed into the air around them producing an incandescent fireball.

The fireball reaches temperatures of 100 million degrees centigrade, five times hotter than the center of the sun, with blast waves producing pressures of millions pounds square inch (psi) (1). Contained in this fireball is the vaporized casing of the bomb, fission particles, and other materials such as dirt and debris which are sucked into it from the earth's surface. As the surface temperature of the fireball drops to about 300,000 degrees centigrade, condensation of the vaporized materials ensues. This material becomes highly radioactive and is released as radioactive fallout. This mass of energy continues its expansion until it reaches approximately one mile in diameter and stretches far into the atmosphere (1).

Approximately, three percent of the energy is released as prompt nuclear radiation, consisting of X-rays, gamma rays, and neutrons which are deadly to about 1.7 miles of ground zero. Forty to fifty percent of the energy released by a one megaton bomb is in the form of light and heat. This thermal impulse travels at the speed of light and ignites fires as far as ten miles away. Buildings, people, plants and animals will absorb most of the heat within a second of detonation (21).

The blast wave of a nuclear explosion causes

the most devastation. Blast wave is caused by highly air, which creates an overpressure (i. e. pressure above the atmospheric pressure) and is followed by winds reaching 150-200 mph. As this blast wave moves out from ground zero it crushes and sweeps everything in this path. When a blast wave reaches about ten miles from ground zero, its forces diminish to about one psi. At five psi overpressure an ordinary framehouse will collapse. With a one megaton explosion this would occur out to 2.8 miles from the epicenter (22).

The radioactive material carried into the atmosphere by the dirt debris sucked into the fireball is heavier than the fission materials of the bomb and begins falling back to the earth as black rain. The lighter materials are carried higher into the atmosphere and the fallout farther downwind of the explosion. Radioactive fallout will cause sickness and death for years (26).

MEDICAL CONSEQUENCES

Primary blast effects include death and injury from crushing as structures collapse, and hemorrhage as circulation responds to the sudden change of pressure. High winds would turn brick, steel, wood and glass into airborne implements of destruction. One author suggests that "at a range of almost fifteen miles, many such objects will have an impact velocity sufficient to have a 50 percent chance of fracturing a human skull (16).

Thermal effects include flash and flame burns. As the probability of massive fires is great, there would also be asphyxiation and lung damage from carbon dioxide and toxic fumes, as chemicals, fuels and the contents of buildings burn. Glancing at the fireball would produce blindness in some and severe heat exhaustion would immobilize many (23).

Radiation injuries would vary according to the size of the bomb and the victim's proximity to it. Estimates are difficult because of the difference in effects of ground versus air bursts, the variation in wind patterns, type of radiation received and the age and general health of the individuals (13). However, it is possible that at least 30 percent of the population of the northern hemisphere would receive doses of at least 250 cGy, with the entire population being exposed to 100cGy (30).

Whether the source is the initial burst, exposure to fallout, or accumulation of low-level radiation during the postattack period, the degree of illiness depends on whether the exposure is local or whole-body, and whether the radiation is deposited externally or internally as particles are inhaled, ingested, or taken in through wounds (14).

Those who do not suffer from one of the acute syndromes may nonetheless suffer damage to the skin, lungs, gonads and eyes. In the population we are discussing, in which everyone is assumed to be exposed to at least 100cGy, there would also be delayed effects, notably cataracts, vascular damage, genetic mutation, and most importantly, cancer induction. One out of 80 persons would likely develop a fatal cancer, while two would develop a nonfatal variety (7).

We have considered a number of injuries and syndromes in isolation from one another. This is somewhat misleading. What medical professionals and their civilian assistants would in fact be faced with is combination of injuries, having a synergistic effect upon one another, so that some conditions which might normally be survivable would be rendered fatal. Even the LD50 whole-body dose of 300-450cGy is not to be too high for post-nuclear conditions (18).

In the event of a nuclear war medical services would suffer almost total paralysis. The vast majority of hospitals and physicians to be in large urban centers, targeted areas where destruction and fatalities will be highest. Even in the best of conditions, where only a single major city had been bombed, there would not be enough medical resources in the United States to provide adequate care for the survivors (32). It must also be noted that even in the improbable event that medical services remained intact, professionals would be severely impaired by their total inexperience in handling radiation-induced illinesses.

ENVIRONMENTAL CONSEQUENCES

Regardless of the scenario and inherent uncertainties of prediction, there is a consensus within the international scientific community that even a relatively small nuclear war would lead to global climatic and environmental consequences of catastrophic proportions (25, 34).

Multiple nuclear explosion would result in millions of tons of fine dust (a megaton blast carries approximately 200,000 tons of dust) being injected into the upper atmosphere. In addition, an estimated 50 to 150 million tons of smoke would be generated from the fires caused by the explosions (8). If these particles where spread over half the northern hemisphere, only 50 percent of the sun's energy and light would pass through to the earth's surface for a period of weeks (15). This phenomenon, called nuclear win-

ter, would cause temperatures in the northern hemisphere to drop between 5 and 22 degrees centigrade within a few days, causing freezing even in summer. Precipitation would be decreased by as much as 80 percent (15).

Long term effects include average annual temperature drops of a few degrees and light reduction of 5 to 20 percent (31). Nitric oxides generated by the nuclear fireballs (a megaton explosion generates 5,000 tons of nitric oxide) combined with the very heated smoke residing in the stratosphere would reduce the ozone layer by 50 percent, causing ultraviolet radiation (UV-B) to be increased by 40 to 100 percent for several years (31). The rising smoke would also displace the ozone layer toward the southern hemisphere. Nitrogen oxides combined with sulphur oxides from the fires would greatly increase the acidity of rains. The relase of large amounts of toxic chemicals and gases during the blasts and fires would cause serious local pollution of air, water and soil.

Ecological effects arising out of environmental changes induced by nuclear war cannot be determined fully, because synergistic effects than individual effects. Global mass starvation of humans would occur due to disturbances of agricultural production and distribution as well as ecosystems. The availability of some fresh water supplies would be restricted due to freezing. Contamination of fresh water and oceanic supplies by radionuclides and the introduction of radionuclides into the food chain would lead further death and disease, as the immune systems of both humans and animals would be weakened (35).

Whether considering effects to ecosystems, such as fresh water, oceanic or terrestrial as a whole, or their individual components, it is of primary importance to recognize that a disruption of sunlight represents a disruption of their energy source and of photosynthesis, the transfer mechanism through which all life forms derive their energy. Thus, any assault on an ecosystem, as a whole or in part, would compromise its existence or ability to function. Moreover, a disruption to processes or components could result in imbalances, such as extinction or reduction of a plant or animal species. This could further lead to increased incidence of mutation, pandemias and death (4, 11, 28, 29, 36).

In addition to the diminished light, all surviving forms of life after a nuclear attack would be exposed to other physical stressors, such as ultraviolet rays, ionizing radiation, radionuclides, cold, varied precipitation, acid rain, fires and pollutants. The extent to which these stressors would diminish and qualitatively reduce life forms would largely depend upon the combination, duration, timing and length of exposures (12).

SOCIAL AND ECONOMIC CONSEQUENCES

Without the ability to remove people from high-risk areas, it has been estimated that less than one-half of the U.S. population would survive the Russian first strike (24). Since the social systems with which we are familiar will crumble instantly, survivors will cling to one another and follow the leadership of the person demonstrating the most knowledge about survival.

Reconstruction is largely dependent upon sources outside the area of devastation. The magnitude of destruction likely to result from a nuclear war makes outside assistance improbable. Help for the injured would be limited, because persons faced with the dilema of helping family or community will usually decide in favor of loyalty to the family (24). Therefore, post-disaster recovery is tied in with close kin relationships. Crisis relocation depends on areas remaining intact for placement of evacuees, transportation systems and food supplies. Since the social systems with which we are familiar will have crumbled, the family unit could possibly be the foundation in rebuilding.

Communication between government and citizens would be slow due to missing links in the communication system including deaths or missing officials and inoperable equipment.

Transportation would be hindered by availability of vehicles, parts for repair and fuel. This would impede distribution of basic commodities such as food, water and medical supplies.

Nuclear war's obliteration of the economic infrastructure in an industrialized society would be "immediate, complete, and indiscriminate" (17). Organized economic operations would be annihilated due to nuclear warheads being focused on urban areas and strategic centers. Industrial production would cease, since there would be no replacement for essential machinery that performed functions relative to economic growth and development. Transportation from storage facilities (primarily located in remote areas) would be unavailables for the distribution of basic commodities, contrary to the information in the report of the Defense Civil Preparedness Agency (3). The radioactive fallout would eliminate economic potencial in agriculture.

Society after the conflict would undergo extreme fundamental changes. The availability of resources and services would be reduced to the

bare minimum, whereas the activities now taken for granted would totally disappear (2).

The government and political structure would be drastically impaired due to the authorities' inability to respond to the emergency. Competition for leadership at local levels could impede relief efforts. The strain of large-scale damage and physical deprivation could cause greater disaffection and hostility (15).

PSYCHOLOGICAL CONSEQUENCES

Current research attempts to address the complexity of psychological impact by drawing historical analogies from manmade and natural disasters.

Several common behavioral changes apparent in survivors of catastrophes are that survivors. suffer from a loss of meaning, loss of will to live, profound apathy and general depressed motivational state (9, 10, 19). At the level of family, a small and very interdependent unit, a variying combination of post-disaster stressors (i.e. the degree of destruction, disorganization, and casualties) introduce multifaceted consequences. Research investigating the effects of war upon children since World War II suggests that children model parental responses to trauma (5, 9). Post-traumatic symptoms include psychosomatic complaints, insomnia, nightmares, chronic fatigue, fear of recourse, fear of people and regressive and overt aggressive tendencies (5, 20, 27).

It is generally acknowledged in the literature that psychological disturbances following a nuclear disaster will be associated with a state of "marked anxiety characterized by fear, apprehension, confusion, and irritability (6). Survivors of the atomic attacks of Hiroshima and Nagasaki observed to display characteristics of psychic numbing, survivor guilt, mental decompensation, various psychoneurological disorders, permanent fear and uncertainty, a lifelong identification with the dead and fear of radiation contamination of future generations (20). It is clear that the psychological reactions of survivors may continue for months or years following a nuclear exchange (20). Long term effects could include demoralization and severe disruption of the social fabric and disruption of interpersonal relationships.

Finally, the issue of help available to survivors of a nuclear attack needs to be addressed. One researcher cites the following factors to be considered: "the number of individuals with mental and behavioral disturbances, the number of psychiatrists available to provide treatment following a nuclear attack, the amount of time required for treatment, the availability of treatment facility and the availability of psychotropic and other drugs for treatment" (6). It seems apparent that no adequate treatment would be available for the vast number of psychological casualties.

Mass casualties anticipated in nuclear industry accidents or nuclear war present the world medical community with an insurmountable dilemma of providing medical assistance to a large number of victims in the circumstances of the ultimate adversity in logistics, expertise and experience. The combined injury syndromes, ranging from acute radiation exposure to internal contamination with organotropic radionuclides to low level radiation exposure, being beyond the access of conventional mass casualty medicine, leaves the prevention of nuclear accidents and nuclear war as the only pragmatic approach to the current world nuclear crisis. Although the global scale confrontation has been successfully deterred by a concept of mutually assured destruction (MAD), current availability of nuclear weapon technology and weapon-grade uranium and plutonium presents a threat of a tactical confrontation or nuclear terrorism. Since the current state of mass casualty management extends beyond the scope of clinical medicine to civil defense preparedness and prevention of nuclear of accidents, the international cooperation in utilizing nuclear energy for the peaceful use remains the only viable option of its lasting positive impact on the changing world. This approach to all levels of human endeavors, from subatomic insights to the space programs, well exemplified by the use of modern nuclear technologies in the diagnostic and therapeutic understanding of the disease processes on the submolecular level, such as positron emission tomography, single photon emission tomography, computerized tomography, magnetic resonance imaging and techniques of linear accelerators in the treatment of previously inaccessible neoplastic disease. The vision of transition from the brink of world nuclear catastrophe to the ultimate benefit to mankind remains a vital global issue at the end of the first century after the discovery of nuclear energy (33).

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Sažetak

MEDICINA U DANAŠNJEM NUKLEARNOM DOBU

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Cilj rada je upoznati medicinsku javnost s alternativama globalnoj nuklearnoj katastrofi i krajnjom koristi miroljubive upotrebe atomske energije za čovječanstvo.

Prividni kraj hladnog rata nije donio značajne promjene u razvoju i usavršavanju nuklearnog arsenala ni na Zapadu ni u Rusiji. Uz prijašnjih nekoliko članica nuklearnog kluba, povećao se broj zemalja koje su sposobne izraditi ili već posjeduju nuklearno oru'je kao i arsenal balističkih raketa za prenošenje nuklearnih bojevih glava u scenariju strateškog sukoba. Pokušaji da se javnosti prika'e drastično smanjenje broja nuklearnih bojevih glava općenito se odnosi na smanjenje zastarjelog arsenala, dok se nesmanjenom brzinom nastavlja razvoj termonuklearnog arsenala s više bojevih glava, uz sve savršenije sustave prijenosa, brzinu reakcije i veću preciznost i u taktičkim i u strateškim scenarijima.

U radu se govori o mogućim fizičkim, ekološkim, socijalnim, ekonomskim, psihološkim i medicinskim posljedicama nuklearnog rata ili nesreće u nuklearnoj industriji kao i o ekološkim posljedicama još uvijek neriješenog problema visokoradioaktivnog nuklearnog otpada. Postavlja se pitanje mogućnosti ograničenog nuklearnog sukoba, stupnja pripravnosti civilne zaštite u SAD i izgleda pre'ivljavanja i oporavka nakon nuklearnog sukoba ili nesreće velikih razmjera u atomskoj industriji. Va'an aspekt rada su i pitanja vjerojatnosti nuklearnog terorizma, fizičke sigurnosti civilnih i vojnih nuklearnih objekata i materijala, nekontrolirane proizvodnje nuklearnog oru'ja i medunarodne suradnje na sprečavanju opasnosti od nuklearnog terorizma globalnih razmjera.

Ključne riječi: medicina, nuklearno doba