

Burn Injuries Among Survivors

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The crash of a partially filled 30-passenger airplane on an island off the coast of Massachusetts required the mobilization of all the emergency medical facilities of Greater Boston, a major surgical center. Yet we are asked to contemplate the possibility of ten thousand, or a hundred thousand, or even a million severely traumatized victims of a military nuclear explosion. Adequate medical treatment for such survivors is an impossibility.

We can talk about how such injuries *should* be treated, but to transfer this knowledge to the practical possibilities of treating the number of victims that have been predicted is categorically out of the question.

The injuries caused by a massive nuclear detonation would come from the various effects of such an explosion. People within and around buildings would suffer extensive traumatic injury, from being blown out of the buildings and from damage by debris. The initial blast effect of the explosion is characteristically followed by powerful winds rising to as much as 180 miles per hour, which would cause a number of severe traumatic injuries.

Most of those who have been crushed, cut, or blasted, but not burned, and who have survived initial injury and reached medical facilities would, in most cases, be expected to require only one

The survivors would envy the dead.

Nikita Khrushchev, 1962

major surgical procedure. Although this might be very expensive in terms of time and material, including a great deal of blood and other support, the victims could then be expected to enjoy a relatively uncomplicated convalescence.

Such would not be the case for burns. Even though heat and light contain only some 35 percent of the total energy of a nuclear explosion, burns would consume a far higher percentage of the post-attack medical resources.

Let us consider the burn injuries that would result from a nuclear explosion and the treatment that would be required.

Patients suffering from anoxia, resulting from most of the atmospheric oxygen having been used up by the extensive fires (especially firestorms), would be rare. If the degree of thermal activity was sufficient to have caused anoxic damage, then usually there would be concomitant fatal incineration.

Both carbon monoxide poisoning and fire-induced anoxia must be distinguished from *pulmonary burns*, which remain one of the major therapeutic problems of thermal damage, one that is largely unsolved. This form of lung injury usually takes from 24 to 72 hours to develop and is not the result of direct thermal damage to the lung. If the heat around the patient's face is sufficient to actually destroy the trachea, bronchi, or lungs, there is almost invariably such devastating destruction of the face and other parts of the skin that the patient does not survive.

The generally accepted theory is that the damage to the lungs results from the chemical activity of noxious products of incomplete combustion. Consequently, this type of burn is characteristic of fires in closed spaces rather than the open spaces that would be more common with a major bomb. Among people confined to buildings, pulmonary burns would be a major lethal factor. In the Coconut Grove fire in Boston some 40 years ago, more than 400 people died, almost all without visible signs of burns. These deaths, which occurred mostly two, three, and four days after the fire, resulted from pulmonary damage now believed to have been from the fumes from the plastic in the artificial palm trees and furniture coverings.

Two kinds of direct thermal injury would occur from a nuclear explosion: one directly from the detonation, the other from the secondary fires following the ignition of available combustible material. These secondary fires would be of at least two sorts. One possibility is a firestorm. Much more certain is the development of a major conflagration, which would be essentially the sort of fire with which we are all too familiar, but enormously increased in scale. This fire would be associated with multiple smaller ones, starting from the breaking of gas mains, the failure of electrical pumps, the lack of water to put them out, and so on. The fires would be spasmodic over a very large area.

People would be exposed to the risks of thermal damage from the bomb itself and from its secondary fires. There is no essential difference in the nature of burns from these two etiologies. Burn damage to the skin results from a combination of the amount of heat and the time of exposure, these factors being very much modified by the presence or absence of clothing, the moisture content of the atmosphere, and other factors. An explosion results in an almost instantaneous exposure to a very high heat level, with damage occurring over an incredible distance; but the nature of the injury is not different from other forms of thermal burns. It simply means that there can be much more severe damage in a very short time if the heat to which one is exposed is very great.

All people seriously injured by a nuclear explosion who also have had a significant amount of radiation injury would be more difficult to treat. Some survivors would have received sufficient radiation to result in death within a matter of weeks or months from the radiation alone. But even with those who received smaller doses of radiation, the damage to the immune system and to blood element regeneration would result in the patient being more prone to invasive sepsis, in less satisfactory healing, and in an increased risk of death from a thermal injury that might otherwise not have been fatal.

Experimental studies have shown that a burn from which a normal animal can be expected to recover becomes lethal if the animal has been previously or concomitantly exposed to non-lethal radiation.

First-degree burns at their very worst are equivalent to a severe sunburn. They may result in some transient dehydration, certainly considerable pain, but under any emergency conditions these require essentially no treatment and must be considered of no particular medical consequence.

Second-degree or partial-thickness burns (the latter term is much to be preferred) are, from the point of view of the surgical problems, almost as severe an injury as are third-degree or full-thickness burns. A deep partial-thickness burn requires essentially the same amount of resuscitative effort, the same difficult nursing, the same elaborate dressings, and the same extensive care during the first three to four weeks. Although these injuries heal from the base and therefore no skin grafting is required, and the eventual problems of resurfacing the patient are a great deal simpler, the immediate problem of care is almost as great as with a full-thickness burn. The two groups should be combined from the point of view of trying to evaluate the early load on the medical system.

Estimating accurately the extent and number of burn survivors in a population exposed to a nuclear explosion is very difficult. The figure might vary by as much as a thousandfold, depending upon specific factors prevailing at the time of the explosion. Even a moderate degree of opacity in the air strikingly reduces the range of thermal damage. Other factors include the season, the time of day, and the extent to which the population had been warned. These conditions partly determine the amount of clothing being worn and whether people are outdoors or not.

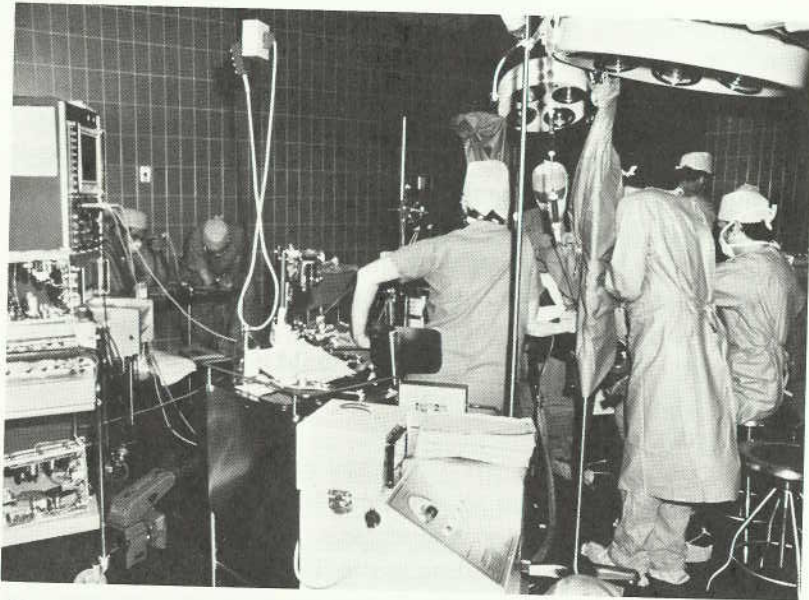
For a one-megaton nuclear explosion, with 10-mile visibility, it has been estimated that third-degree or full-thickness burns might be expected within 5 miles; second-degree or partial-thickness burns within a 6-mile radius, and first-degree burns within 7 miles. If the atmosphere were sufficiently opaque to reduce visibility to 2 miles, then the second-degree zone would be

allograft a graft taken from another person, not an identical twin.

anoxia absence of oxygen.

sepsis presence of various pus-forming and other pathogenic organisms, or their toxins, in the blood or tissues.

triage classification of a large number of casualties into three groups: those who will survive without any medical help, those who will die no matter what treatment they receive, and the priority group of those who will survive only if they receive medical treatment.



Burn treatment. Large numbers of highly trained personnel are required. Such personnel will not be available after a nuclear war. (Shriners Burns Institute, Boston.)

reduced from 6 miles to something under 3 and the others changed proportionately.

Unfortunately, burns are the form of trauma that characteristically demand the largest amount of medical assistance. No injury can be counted on to use up more hospital facilities than a severe burn. Triage would be very difficult, and a great many patients treated for extended periods might still eventually die from their injuries.

The burn literature has been filled over the last ten years with reports of progress in salvaging the severely burned. Many new methods of infection control have come into use, including various surface antiseptic agents and topical antibiotics. The surface control of infection has prevented the conversion of partial-thickness to full-thickness burns by sepsis and has strikingly improved overall results in burn salvage. There also has been much effort to control systemic infection, both by the use of antibiotics and by elaborate isolation techniques. "Life islands," in which patients are isolated in a plastic enclosure, and laminar flow units, in which the air is regularly replenished and replaced so that



Isolating the burn victim. A plastic tent provides a sterile environment for the treatment of a severe burn. Pathogenic organisms are screened out both by the tent and by a constantly recirculating air flow filtration system inside. (Shriners Burns Institute, Boston.)

bacteria are swept away, are recent innovations. All of these methods have helped reduce death from infection.

Another recent development is the early surgical excision of burns. Although it is usually not safe to excise more than one-fifth of the patient's body surface at one time, surgery may be carried out on the first or second day after the burn, and with maximum support again on the fourth, and so on, ending with as much as 80 to 90 percent of the skin being excised. Massive excision has been combined with immunosuppression to allow for the use of typed allografts taken from living donors or cadavers. Some dramatic results are possible with these methods, although they are still cosmetically relatively grotesque.

It is absolutely essential to recognize that any really severe burn may require as many as 30 to 50 operations, both immediate

and delayed, and months and months of hospitalization. This care imposes immense strains on the medical facilities available. With the newer and more dramatic methods, there is at least the possibility, if sufficient material and personnel are poured in, of salvaging burns in the 85 to 90 percent range.

Triage is much more difficult when the physician is faced with an enormous group of patients sustaining 20 to 90 percent burns who might survive if treated. (Except for burns of the hands and face, I exclude burns affecting under 20 percent of surface because most of these can be treated relatively easily.) What is involved in treating large numbers of severe burns?

Some years ago the Shriners of North America, who had for years donated large sums to look after orthopedically crippled children, became interested in building specialized burn hospitals for children. Their plan was to start with three burn units and then to expand, possibly adding another 15 or so to match the number of orthopedic hospitals they were already maintaining. These initial three units were built in Boston, Galveston, and Cincinnati. In the 15 years since these three 30-bed hospitals were built, it has not been practical to build even one other unit, because the three burn units, with a total of 90 beds, consume a budget similar to that of nineteen orthopedic hospitals, most of which are of comparable size.

The cost of running a single 30-bed hospital, where half of the beds are reconstructive and where there would rarely be more than ten acute burn cases at one time, is in the neighborhood of \$4 million per year. The United States has approximately 1000 to 2000 so-called burn beds in specialized institutions. Each burn patient requires specialized individual nursing for quite a long time. At most, one nurse can look after two patients.

Severe burn cases require not just one major operation but may need general anesthesia every other day and regular trips to the operating room for weeks or even months. Elaborate dressings and the application of antibiotics or at least antiseptic agents are necessary. The patients require large amounts of blood, albumin, and other human blood derivatives. They may need enormous areas of allografts, but after a nuclear war, obtaining sufficient quantities of these from cadavers may be difficult, because many of the dead would be in highly radioactive areas or be contaminated radioactively themselves.

Whereas most traumatic lesions are treated definitively imme-



A child with severe leg burns requiring extensive surgical treatment in a highly specialized hospital. Severe burn cases may need regular trips to the operating room for weeks or months. (Shriners Burns Institute, Boston.)

diately, and the victims either recover or die, burns are peculiar. The burn patient is not so ill during the first 12 to 24 hours. I have seen a number of older patients with 40 to 50 percent full-thickness, clearly fatal burns who, for the first 12 to 24 hours after their injury, appeared in reasonably good condition. They were capable of consulting their lawyers and doing whatever needed to be done. After this initial period the patient becomes sicker and sicker, and this critical hovering between survival and death may go on for weeks or months.

Once a burn has been initially resurfaced, it may need months or years of reconstruction. And even with all of this, anyone who is discriminating or humane would recognize that the end results are indeed pathetically poor. It is very difficult to estimate the cost of such cases in dollars because, to the best of my knowledge, no health program or insurance pays adequately for burn care. Blue Cross/Blue Shield and similar insurance programs admit that they cannot afford to pay the true cost. Nonetheless, it is reasonable to put the cost at anywhere from \$200,000 to \$400,000 for a severe surviving burn case.

Treatment of a Severe Burn

20-year-old man
85% of body surface: full-thickness burns (from a gasoline explosion)
33 hospital days (died on 33rd day)
501 transfusions:
 fresh frozen plasma 281 units
 fresh frozen red blood cells 147 units
 platelets 37 units
 albumin 36 units
6 operations
medical personnel hours 4900
approximate daily cost \$3500

From John F. Burke, M.D., Chief of Trauma Services, Massachusetts General Hospital, July 1980.

Even though there are 30-bed burn units, such as the Shriners or those at large general hospitals, they can handle only two or three fresh severe burns at once. If a large group of such burns occurred in a major accident, they would have to be distributed for effective treatment.

Major burn disasters of recent years—the Coconut Grove and Hartford Circus fires—and various plane crashes have resulted in very few survivors of major burns. Initially following a nuclear attack, there would be thousands, or even tens of thousands, severely burned immediate survivors. Even the most conservative calculation of thermal injuries resulting from an isolated one-megaton or “minimal” nuclear explosion, with hypothetical preservation of all U.S. medical facilities and the availability of immediate and perfect triage and transportation, shows that what we consider to be one of the most lavish and well-developed medical facilities in the world would be completely overwhelmed. It is impossible to imagine the chaos that would result from a larger explosion in which the hospitals themselves were partially destroyed and where there was no possibility of significant triage or inter-center transportation. The medical facilities of the nation would choke totally on even a fraction of the burn casualties alone.

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Survivors of Nuclear War: Infection and the Spread of Disease

Herbert L. Abrams, M.D.

The devastation and chaos that would follow an all-out nuclear war and the potential for regression to a social structure unknown to twentieth century industrialized society have been well emphasized. But the nature of the medical problems that would confront survivors has not been widely conveyed. The effects of burn, blast, and radiation have dominated discussions of the post-attack period. In the intermediate term, however, infection and the spread of communicable disease would represent the most important threat to survivors.

In depicting a massive nuclear exchange, we will assume that the United States has undergone a 6500-megaton attack, the so-called CRP-2B model used by the U.S. Federal Emergency Management Agency in civil defense planning. In terms of yield, it

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