Nuclear Triage and the Dirty Bomb

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"*...the only thing we have to fear is fear itself*"
-- F. D. Roosevelt, March 4, 1933

Triage is "the sorting of and allocation of treatment to patients and especially battle and disaster victims according to a system of priorities designed to maximize the number of survivors."[1] Disaster victims are often grouped as follows:

1) those who can remain healthy with no medical treatment;
2) those who can benefit from medical treatment; and
3) those who are beyond available medical treatment.

This division allows medical personnel to concentrate on those who can benefit most from immediate treatment. Triage is practiced for most disasters. However, *nuclear triage* introduces a new concept.

Nuclear triage addresses the beneficial, as well as the debilitating, effects of ionizing radiation in survivors of a disaster such as a nuclear accident, explosion, or bomb. Based upon abundant evidence, reviewed briefly below, it is estimated that exposed persons outside the blast area will benefit from the residual radiation of a dirty bomb. Nuclear triage requires considerable education and a change in current concepts for the medical profession, health physics people, and the general public.

The most readily available, highly radioactive ingredients for dirty bombs are cobalt-60, cesium-137, and strontium-90 from spent medical and industrial radiation sources. They all have pene-trating gamma rays and Sr-90 has an abundance of beta rays. Their lethal radiation should be a warning to those who would prepare, store, or carry a dirty bomb. Undoubtedly, terrorists anticipate more harm and deaths from fear and panic than from radiation.

PROLOGUE

Large doses of ionizing radiation are harmful.

- In 1961, some Mexican boys played with a discarded Co-60 medical radiation source. Four died and another had serious radiation sickness from the gamma radiation.[2]
- In 1987, a junk dealer in Goiania, Brazil, opened an abandoned radiation therapy source with about three ounces of Cs-137 (chloride) powder.[3] About 250 persons were contaminated; four died with radiation sickness.
- In 1997, 11 army recruits in Georgia (formerly part of Russia) were hospitalized with radiation sickness after being too close to containers with a small Cs-137 calibration source.[3] They all survived, following extensive surgery.
- In 2001, three Georgian soldiers became sick within hours after warming themselves overnight near canisters containing 40 kCi of Sr-90. They developed extensive skin and tissue burns from the combination of beta and gamma rays of Sr-90. About 900 of these small Russian electric generators (mobile nuclear power plants in titanium-ceramic containers about one cubic foot in size) were made for radiotransmission and lighthouses in remote areas; fewer than 30 have been found.[3]

Conversely, *low-level irradiation* is beneficial. To cite one of many examples (waste management, etc.), waste Co-60 was sometimes incorporated into steel shipped worldwide from

Jaurez, Mexico.[2] Such radioactive steel was used in the construction of 1,360 housing units in Taipei in 1982-1984.[4] Over the next 20 years, gamma rays from the Co-60 provided unintentional low-level, whole-body irradiation to about 10,000 working class Taiwanese. The exposures were: an average of 0.5 cGy/y for all people, >1cGy/y for 50% of the people, and >5 Cgy/y for 10% of the people; the maximum exposure was 64 cGy/y. (The average exposure in the United States is 0.13 cGy/y.) After 17 years, the cancer mortality rate of the exposed population was only 3% that of the Taipei population.[4] Unfortunately, money is not available to provide a rigorous epidemiologic study.

"THE DOSE MAKES THE POISON"
(Paracelsus, 1493-1541)

High and low doses of most things produce opposite effects (hormones, vitamins, drugs, and radiation). Low doses are biopositive—often beneficial. "Low dose" is defined by the threshold in each study. High doses are bionegative—usually harmful. The amount of harm from doses exceeding the threshold is proportional to the logarithm of the dose. Overwhelming evidence from over 3,000 scientific reports shows that low doses of ionizing radiation are stimulatory or beneficial.[5,6,7] Few of those reports concern the one-fourth of all hospital patients who receive x rays or radioactive compounds used in diagnosis and treatment. Many patients who walk out the door of a hospital could not pass the radiation screening test for workers at a nuclear power plant, due to the residual radiation in their bodies following treatment. In fact, some evidence indicates that ionizing radiation is required for life.[6, 8] Learning about its beneficial effects will help abolish fear of low-dose irradiation.

The importance of "dose" is best known from our exposure to the sun. The ultraviolet rays of the sun evoke the production of vitamin D in our skin. The American Academy of Pediatrics recently announced that many mothers get insufficient sun to provide enough vitamin D in their milk for their infants to make strong bones; therefore, lactating mothers should take a vitamin D supplement.[9] Sunshine also tans the skin; this reduces the absorption of ultra violet rays. Sunburn warns us that too much sunlight is harmful. Excess exposure can cause skin cancer.

For ionizing radiation, the threshold between biopositive and bionegative reactions (as determined in mammals) is about 10,000 times our background level.[6] For acute, whole body exposures, the threshold in both humans and other mammals is about 7 cGy from gamma or x rays.[6] To put these values in perspective, the dose for mammograms is usually less than 0.2 cGy to the chest.[10] Radiation therapy doses for breast cancer (not whole body) often exceed 500 cGy.

The graph in Figure 1 shows a typical hormesis curve; low and high doses evoke opposite effects. This example comes from 31,710 Canadian women with tuberculosis who received multiple fluoroscopic examinations to the chest during therapy. The breast cancer death rate of those who received several low doses of x rays, 10-19 cGy total, was only 66% that of the controls.[11] The threshold was about 30 cGy. The authors misdirected our attention to this example of hormesis by stating "...the most appropriate form of dose response relation is a simple linear one..." (with no threshold). This misrepresentation was verified by BEIR V: "The committee preferred... models in which the excess relative risk is linear in dose..."[12] In contrast to those inaccurate statements, Pollycove noted that women who received several low doses (15 cGy) had a relative risk of breast cancer that was significantly less than that of controls, $p<0.01$.[13] The vertical lines in the graph define 1 SD (standard deviation) and show that women receiving a total exposure of 55 cGy had no more breast cancer deaths than did the controls.

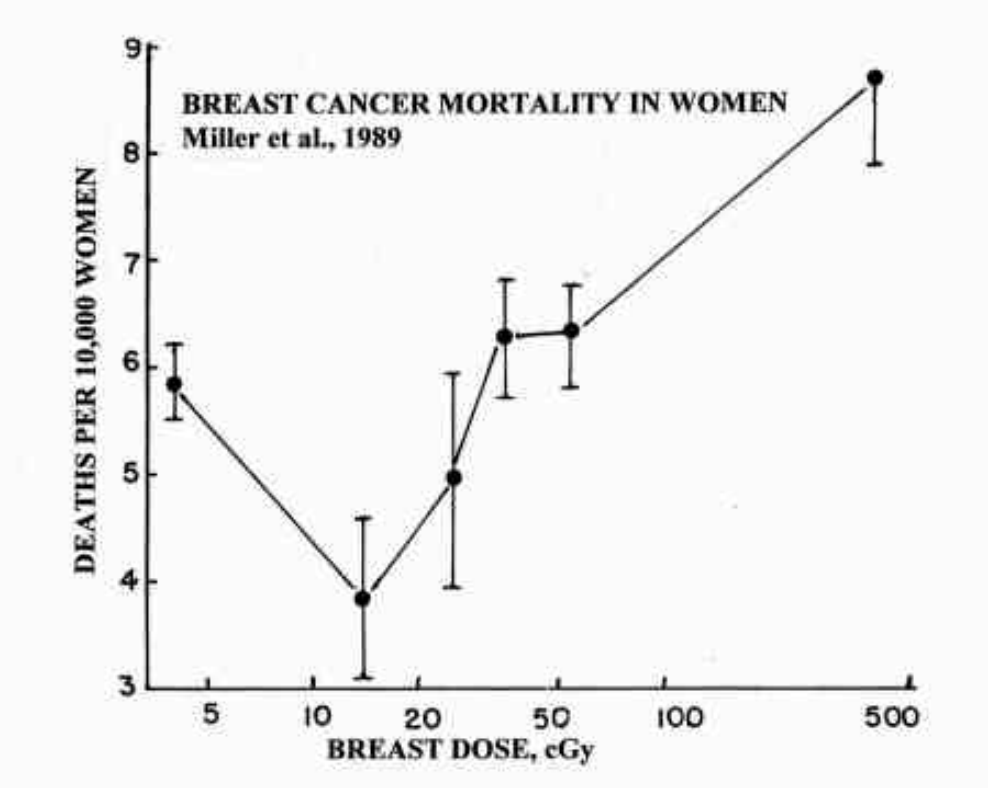

Figure 1. *A typical hormesis curve showing that low and high doses evoke opposite effects (the study here detailed deaths from breast cancer in women)*

This curve is comparable with mortality rates in Japanese survivors of atomic bombs. When compared with controls, the mortality rates for those exposed to the lowest doses were 0.82 for leukemia and 0.93 for solid cancers.[14, 15] I find no credible study proving that low-dose irradiation is harmful.

THE CHALLENGE

A $1,000 prize is offered for the first person (date and time received*) who sends a reference for **one valid scientific study** in English showing that low levels of ionizing radiation are harmful in normal (not genetically deficient) humans. Harm is defined as an increased mortality rate from either leukemia or total cancer, or a decreased average lifespan. Where is one good study (no epidemiologic pockets) proving harm from low-dose irradiation?

When this challenge was issued to the U.S. National Council on Radiation Protection (NCRP) committee at its April 6, 2000, a public forum, the **British** member** answered:

1) the Japanese atom bomb victims; and
2) the Stewart study of cancer deaths in fetuses of irradiated mothers.

Both fail!

1) When compared with controls, **Japanese atom bomb survivors exposed to low doses of radiation** had:
   a) **decreased** leukemia mortality rates ($p<0.01$);
   b) **decreased** total cancer mortality rates ($p< 0.001$)[14,15]; and
   c) an **increased** average lifespan.[16]
2) In their14-page publication, Stewart *et al.,*

report that low doses of radiation were not harmful: "**Our final conclusions are that foetal irradiation does not account for the recent increase in children malignancies,** ...."[17]

NUCLEAR TRIAGE

There were two catastrophes which provide good dose-response data for nuclear triage. About 86,520 Japanese survived five years following exposure to atom bombs.[14] Over 60% had no, or beneficial, effects. Total cancer mortality rates increased for those receiving more than 20 cSv. Fewer than 8% received more than 50cSv. Only 0.54% (470 persons) received over 200 Sv.[15]

The 1986 accident at Chernobyl exposed over 100,000 residents and 800,000 evacuation and clean-up workers.[18] Of the 237 persons hospitalized with radiation sickness (less than 0.3% of those exposed), none died who had received less than 200 cGy. The death rate was 2% for the 50 who received 200-400 cGy, 33% for those exposed to 400-600 cGy, and 95% for those who received over 600 cGy. Jaworowski reports "No increases in overall cancer (and leukemia) incidence or mortality have been observed that could be attributed to ionizing radiation".[19]

A third possible cohort, persons exposed during the Pacific nuclear testing, is not useful because doses were not well monitored. Operation CROSSROADS (1946) at Bikini Atoll in the Marshall Islands involved 235 nuclear bomb explosions which exposed about 40,000 U.S. Navy, 6,400 U.S. Army, and 1,100 U.S. Marine personnel. "Because available data were not considered suitable for epidemiologic analysis, we base this study on exposure surrogate groups."[20] There were 32,000 U.S. observers of the later (1951-57) nuclear tests. Both solid cancer and leukemia mortality rates decreased as exposures increased.[6] As shown by the estimated 30 cGy for one engineer (Rod Morrison worked in 40 nuclear blasts), doses were substantially higher than those recorded.[6]

Brucer, the father of nuclear medicine, summarized nuclear triage for the medical profession.[2]

- few people survive after receiving over 600cGy;
- about 2% die after receiving 200-400 cGy;
- none die of radiation sickness after receiving less than 200 cGy; and
- less than 100 cGy is considered a trivial dose.

DIRTY BOMBS

There are major differences between atomic and dirty bombs. The main ingredients of atomic bombs, uranium and plutonium, have relatively long half-lives and low levels of radioactivity. Samples of these pure elements are warm when held in the hand. Much of their radiation consists of alpha rays, which do not penetrate the skin. It is the products of atomic explosions that are highly radioactive. This is the reverse of conditions for dirty bombs. A dirty bomb is itself dangerously radioactive; its ingredients will have lethal levels of radioactivity. Explosion of a dirty bomb disperses the products and reduces the levels of radioactivity.

Dirty bombs may have a variety of radioactive materials encased within a "normal" bomb. Large doses of radiation from neutrons or alpha rays would be most unusual. The most readily avail-able materials are radiation sources from medical treatment centers in the west and portable nuclear reactors in the east. Radiation from their concen-trated gamma rays makes dirty bombs more dangerous for those who make, store, and transport them than for the victims subjected to fragmented bits of radioactive material. Persons who prepare, store, carry, and detonate dirty bombs constitute a high-risk group for radiation sickness. Many will develop radiation sickness, and some may die.

General rules for victims of dirty bombs include:

- Call 911 to alert nearby police and hospitals;
- Help fellow survivors without provoking arguments or panic;

- Walk 100 yards from the blast/debris area and drifting dust. Remember, wind will disperse the particles; rain will deposit them;
- Clean those in the blast area immediately;
- Use gloves to remove radioactive particles from skin or clothing;
- Remove outer clothing;
- Wash, do not rub, exposed skin;
- Be alert to the needs of medical personnel; trauma from the blast includes many injuries other than radiation sickness; and
- Keep roads open for emergency vehicles. Streets may be unnecessarily blocked by gawkers, media, and survivors wanting to escape the area. Predictably, many more people will be killed from the escape panic and the effects of the blast than by irradiation.

The effects of the explosion blast—flying debris, deprivation of facilities, sorrow, despair, and fear (hysterical radiophobia)—are separate considerations. For example, fear of physically detectable, but biologically negligible, radiation from the 1986 Chernobyl reactor explosion evoked thousands of needless suicides in northern Europe.[18]

Items to be considered and treated separately from radiation sickness include:

1) physical harm from the air blast, heat of the explosion, flying debris, and falling structures;
2) radiation hysteria (crowd action, suicides, and abortions);
3) the depredation of environment (lack of water, food or health care); and
4) radioactive fragments should be carefully removed from the area.

It is of prime importance to differentiate between low and high doses of radiation: 1-10 cGy/y is considered a healthy level. To clean below 1 cGy/y would be counterproductive. Radiologists and health physics personnel should evaluate total body doses for exposed persons. Adherence to guidelines will help to "maximize the number of survivors". A guide for nuclear triage for those exposed to radiation from dirty bombs is suggested below.

NUCLEAR TRIAGE FOR DIRTY BOMBS

Group 1 (0.1-10 cGy)

Exposed persons outside the blast/debris area can simply walk about 100 yards away from the area where particles are deposited. These exposed persons should require no medical treatment for radiation sickness. They may need psychological help to understand that low doses of ionizing radiation cause no harm. These exposures will lower leukemia and cancer mortality rates in this cohort.

Group 2 (10-200 cGy)

Persons in the blast area should be examined for radiation sickness. They should be cleaned of radioactive debris: washed thoroughly, embedded material removed, and clothing replaced. Since a dirty bomb disperses, rather than creates radioactive material, the dose is diluted. The Japanese atom bomb victims and the nuclear worker studies suggest that most persons (over 90%) in the blast area of a dirty bomb will survive; however, their cancer mortality rate may increase. Those exposed to more than 100 cGy may need medical attention.

Group 3 (200-600 cGy)

In order to maximize the number of survivors, medical treatment should be concentrated on these persons. They will have some degree of radiation sickness. Depending upon the dose received, they will be helped by time and medical treatment.

Group 4 (>600 cGy)

Excepting the perpetrators, it is reasonable to anticipate that very few persons will receive lethal

doses of radiation from a dirty bomb. Few persons (less than 10%) exposed to this much radiation will be expected to survive. All should receive comfort and care.

FREEDOM FROM FEAR OF RADIATION

Misinformation from our government advisory committees is the root of our fear of ionizing radiation. Their reports promote policies based upon a false dogma, "all radiation is harmful." In their malicious deceit, the committees extol results showing harm from large doses and routinely ignore thousands of valid scientific studies showing the biopositive effects of low doses of ionizing radiation which can be beneficial.[5,6,7] This fear of radiation is promulgated by the media (including medical and health physics texts) and is the basis for harmfully stringent governmental actions and laws. These fallacious recommendations are directly responsible for millions of premature cancer deaths.[21] There is no valid evidence proving that low levels of ionizing radiation cause cancer mortality in humans. Contrary to our national committee recommendations, undeniable evidence shows that low-dose irradiation decreases cancer mortality rates.

Accidents among nuclear workers simulate modes of radiation exposure for survivors of dirty bombs: cuts, impinged material, swallowing, breathing, and spilled liquid on the skin. Over 120,000 nuclear workers in seven nuclear plants were contaminated with radioactive materials in a variety of ways. In studies involving over seven million person-years, the cancer mortality rate of accidentally exposed nuclear workers was only 51% that of very carefully selected controls doing the same work.[21] Small, acute doses of ionizing radiation are beneficial.

Ionizing radiation is probably essential for life.[8] The evidence suggests 50 times our background radiation would be optimum; 1000 times ambient radiation would not be deleterious. Low doses of ionization activate our immune system. As the evidence shows, this leads to fewer respiratory infections, lower cancer mortality rates, and increased average life spans. Predictably, over 90% of the exposed survivors of a dirty bomb will have beneficial, or no detectable, effects from ionizing radiation. This is the crux of triage for dirty bombs. Hormesis is a newly recognized component of nuclear triage. Persons who receive low-dose irradiation become healthier and live longer than non-irradiated persons.

NOTES

* Respond to rad-sci-health@wpi.edu, or RSH, Box 843, Needham, MA 02494, USA.

Why do we have British members on our **national committees? This is representation without taxation! Consultants, yes; members, no!

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