Radioactive Terrorism

TRAINING FOR PREPAREDNESS

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Introduction

- Characteristics and Consequences of Terrorist Incidents Involving Radioactive Materials
- Keep in mind that we have no past experience to share, so we are hypothesizing what might happen, and suggesting how to prepare for a response.

Topics of Discussion

- We have experience with Atomic Bombs, Chernobyl, T.M.I., and Weapons of Mass Destruction (WMD).
- We have little experience, if any, with Radiological Dispersal Devices (RDD), or Dirty Bombs.

Radiological Dispersal Devices

1. Small devices generally highly localized sources
2. Large quantities over large areas.

A “dirty bomb”, how “dirty”?
The “dirt” is radioactive contamination.

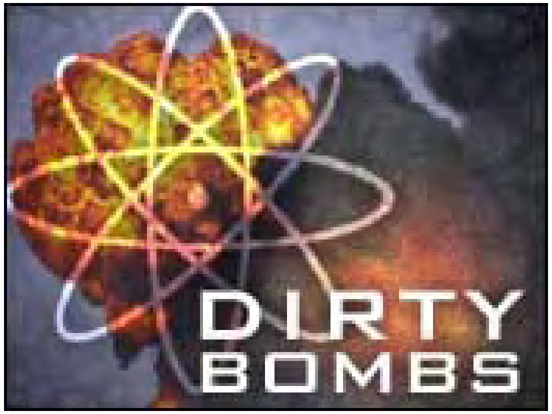
Radioactivity vs. Radiation

1. Radioactivity describes the intensity of radio-contaminated material
2. Its usual units are in Curies or Bequerels
3. Radiation usually means ionizing radiation, and can be either alpha, beta, gamma, X-rays, or neutron exposure in air or to a person
4. The unit of radiation exposure is the Roentgen
5. The unit of absorbed dose is the RAD
6. The unit of Dose Equivalence is the REM
7. 1 REM = 1 RAD x Quality Factor (1), used to equilibrate the greater harm of some types of ionizing radiation

Some Clarifications

1. Being irradiated does not make you radioactive. You become radioactive by skin contamination or ingestion or inhalation of radioactive materials.
2. The term “Hot” used in this presentation usually does not refer to thermal intensity, rather a greater intensity of radioactivity

How Dirty a Dirty Bomb?



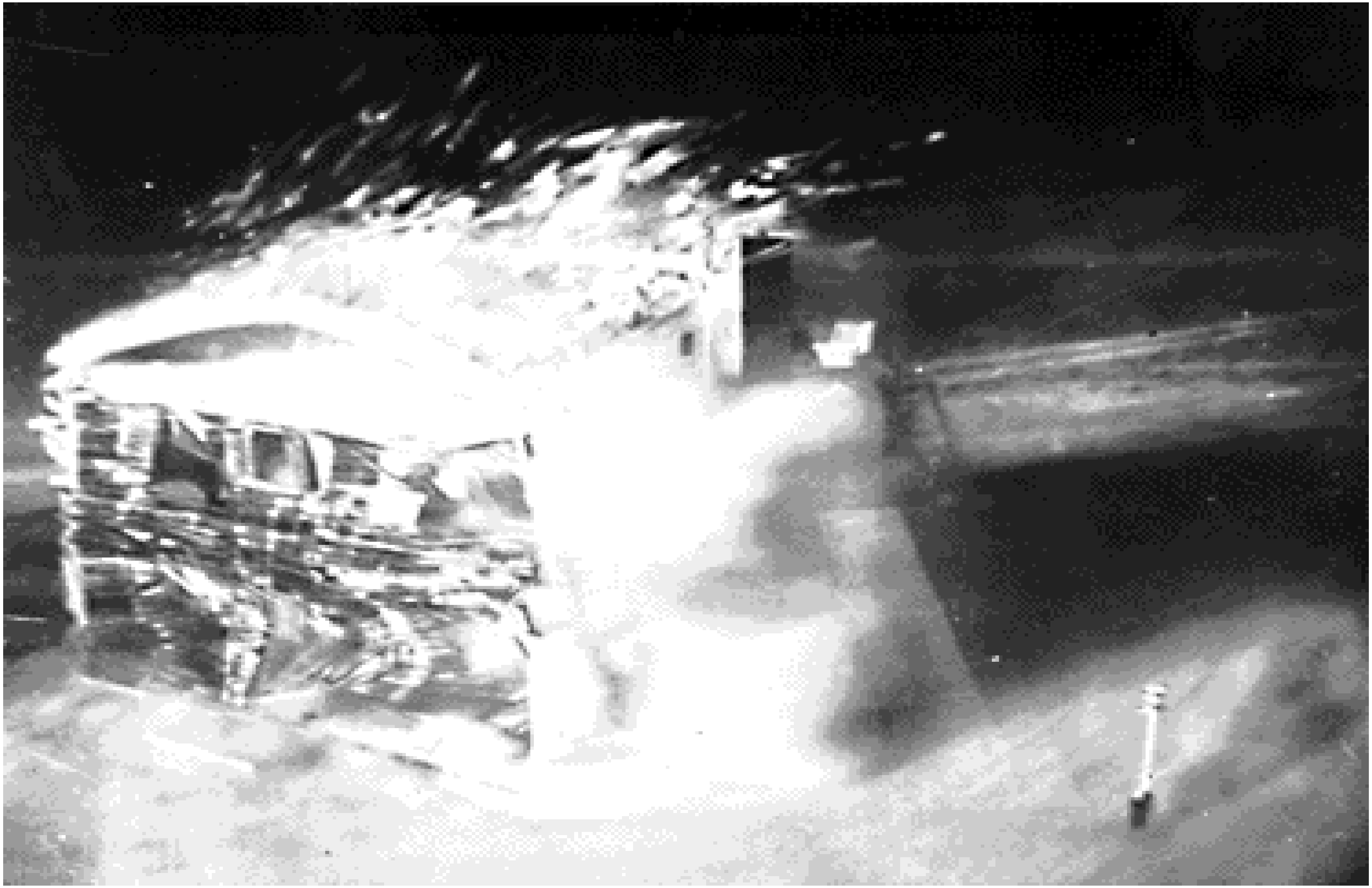
1. With a small dirty bomb the primary objective is to cause fear and chaos by disrupting the social order.
2. It could be a small package left in a shopping mall or an athletic stadium with an explosive and a timing device mixed with various radioactive materials

Large Scale Devices

A radioactive liquid could be put into a water reservoir or lake. A plane, hot air balloon, or ultra-light could spray or drop radioactive materials over a city or in a stadium, etc.

Bombing or crashing a jet into a nuclear reactor would probably release very little radioactive material, but a small nuclear weapon detonating in a city or stadium would be catastrophic (Tom Clancey's "A Sum of All Fears").

A book and movie



Types of Ionizing Radiation

1. Alphas – can be stopped by a few inches of air or a piece of paper, but if ingested or inhaled, they can be very hazardous.
2. Betas – can be stopped in a few feet in air, or by aluminum or glass, they too are not good if ingested or inhaled, but not as bad as alphas.
3. Gammas (X-rays) – go for miles in air, need lead to stop them. They create betas inside the body by scattering. They pass through the body.
4. Neutrons – go for miles in air, need water, boron, paraffin, charcoal to stop. Slower neutrons called thermal neutrons impart the most biological harm.

Where Could a Terrorist Get the Radioactive Sources for a Dirty Bomb?

Technetium-99m (Tc-99m) could easily be obtained from radiopharmacies, hospitals, or doctor's offices. It would be in liquid form. The radioactivity would self-destruct by radioactive decay very rapidly with it's 6 hour half-life (the amount of time that it takes to decay away ½ of the radioactivity). Nuclear medicine patients get this material every day. Not too scary, but readily available, and easy to steal.

More Radionuclides

- Cesium – 137 (Cs-137) is in many, but not all, hospitals locked in a lead safe in a locked room, usually in the basement. The crook would probably be suicidal to try this, as he/she would get a lot of radiation exposure, but….once the brachytherapy sources (about 2 mm x 10 mm) are stolen, they could be sawed or cut open to get the Cesium Chloride salt out. This loose salt with a bomb would expel the radionuclide with a 30 yr, half-life over a large area that would take a long tedious time to decontaminate, not to mention more serious human contamination. Not good!

Transuranics

If a crook could steal radioactive materials from a reactor, national laboratory, a research or commercial facility, or a foreign national source, it could be a transuranic, or fissile material. It could cause a small nuclear blast. Or, it could contaminate an area with many neutron and gamma-emitting long-lived radio-contaminants. The half lives would be in thousands of years or more. Real nasty stuff.

Consequences of a Dirty Bombing

Assuming no adjunct biological or chemical pollutants, the physiological harm will probably be minor, with only an increase in the risk to long term effects- years later (no immediate deaths from radiation). So mostly the effects will be psychological-enhanced by media-hyped-hysteria and chaos. So, how do we modify or minimize this? Radiological containment, and psychological reassurance from those that can be trusted.

Stan Honda / AFP

Radiological Containment

Limit the area effected to as small as possible, as ascertained with Geiger Mueller Survey Meters (Geiger-counters). The public and first responder's clothing will minimize most contamination, exposed areas can be washed off with water at the site, as soon as possible. No need to contain wash-off at the site. Pocket ionization chamber dosimeters, if available on first responders will monitor personnel exposure in the recovery and clean-up efforts. Although they cost over $100 each, they give an immediate read-out, unlike film badges. They also are easily broken, if they drop. Geiger counters ($500-700) will be very useful to measure relative "hot spots", so personnel time spent for recovery of victims in the "hot spots" can be calculated.

CD V-750 CHARGER / ZEROING UNIT
CD
0046581

Three inexpensive G.M. Survey Meters

In $100-250 range, found on web

Containment Continued

No areas should be “too hot” for rescue efforts, as an individual is allowed 25-50 REM as a lifetime dose for life-saving efforts. But, these Planned Special Exposures (PSE) should be under the direction of a health physicist, or other radiological expert. The occupational exposure limit for all radiation workers is 5 REM/yr-if exposed on a regular basis. 5 REM = 5000 mREM. 500/12 mo.= 416 mREM/mo. 416/160 hrs. per mo. = about 2 mR/hr. So, the goal is to keep exposure averages to < 2 mR/hr. Pocket dosimeters read in total mR accumulated. Geiger-counters read in mR/hr.

Containment Continued

A Geiger counter that reads 600 mR/hr means that if you are in that area for 5 minutes you would receive 600/12 = 50 mR or 1/100 your annual limit. Radiation exposure delivered in a short time has more biological effect that the same exposure spread out over a very long time, as you body has more time to recover and repair some cells. So rotating staff into high exposure areas for life-saving efforts lessens personal impact. Low level radiation exposure is not necessarily harmful. As a matter of fact, some studies show that low level radiation exposure reverses negative biological trends. This is called “radiation horemesis” (which is not prostitute mice-a little humor there).

Continued Containment

The use of plasticized-paper jump suits with integral shoe-covers and respirator masks at the bomb site by first responders at the site will help tremendously in reducing their exposure to contaminants topically, by ingestion, or inhalation. Slight rips in the suit is not a big deal, as it might be for a biological or chemical contaminant scenario, because you still have street clothes under the suit as a second line of defense. The jumpsuits may allow you to save your clothing used during rescue.

Gene J. Pusakr / AP

The Hazard of Radiological Contamination

Radiological contamination is radioactive material in liquid or dirt on the surface of something that can rub off on you. The hazard is from the radiation exposure you get while near this source. If you rub it onto your clothing, albeit a smaller quantity now, it is very close to your skin/body until you take the suit or clothing off. If you get it on your hands, then you could inadvertently spread it into your mouth or nose. A Geiger-counter can tell you what surfaces are “hot”, or contaminated. From radioactive material on a victim riding in an ambulance with first responders, the exposure to EMTs will be very small. Use universal precautions and distance (as best as possible), and you’ll be fine. The radioactive contamination cannot jump onto you without you touching the contaminated victim. Ionizing radiations from the contaminant will expose you, but to a miniscule extent.

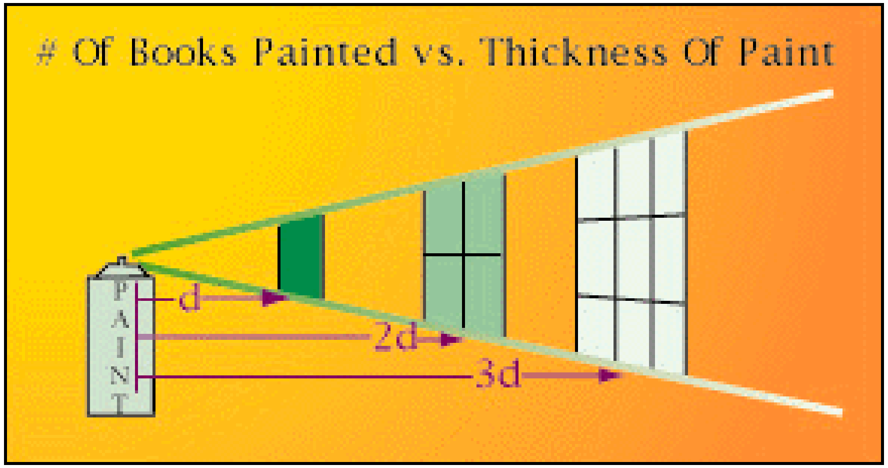
The Cardinal Principles of Radiation Safety

TIME, DISTANCE, AND SHIELDING

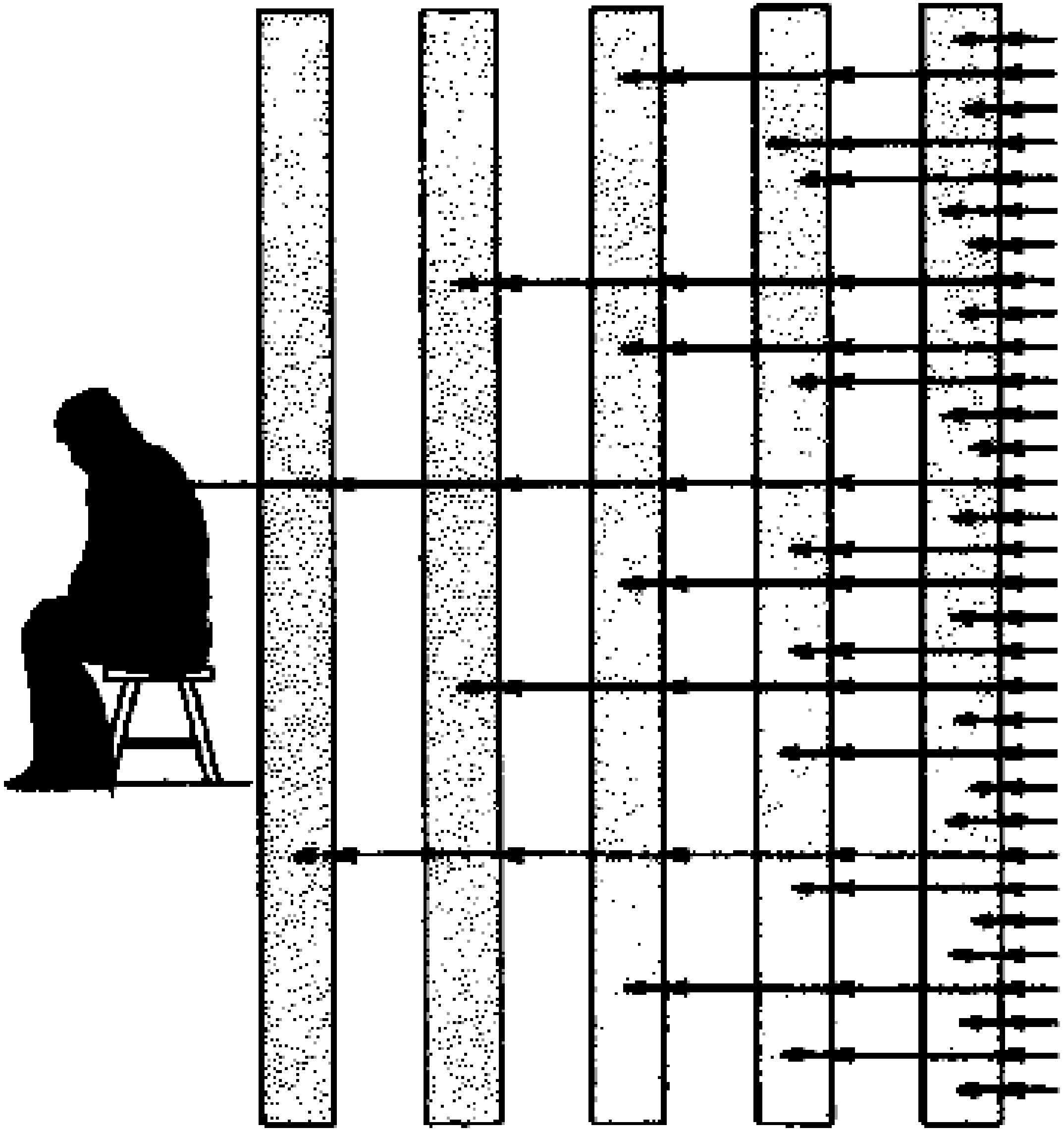
1. TIME - minimize your time around the source of exposure to only that absolutely necessary
2. DISTANCE - maximize your distance from a known exposure source (Inverse Square Law helps you more than you might have thought)
3. SHIELDING – interpose something between you and the source beside air- another person, a barrier, lead, etc.

DISTANCE and the Inverse Square Law

Radiation intensity follows the inverse square law, which means that as you get twice as far from a source, the intensity does not drop by ½, rather by ¼. If the exposure at one foot from a source is 16 mR/hr, then at 2 feet the exposure is only 4 mR/hr not 8 mR/hr, following the rule $1/d^2$ x exposure at one foot = new exposure at "d" distance.



The Effect of Shielding



How Do We Initially Know that a Bomb Blast was a Dirty Bomb?

Unless the terrorist discloses that it was a dirty bomb, as an afterthought, first responders will be relied upon to verify the risk. These first responders will be firemen or police, not usually EMTs. Dispatch messages from a central command will be most important in divulging this information. The immediate crowd response will be hysteria from “a bomb blast”, unless someone announces that it was a “dirty bomb”, which may up the ante to chaos. If homeland security had a “heads-up” on a possible radioactive bomb prior to detonation, but announced it at a large gathering, chaos could also ensue. Continued errors in such announcements will erode trust by the public, and the “crying wolf” syndrome may occur to modify hysteria. If homeland security got to it before crowds assembled, then the worst case scenario could be avoided.

Threat Levels for Dirty Bombs

4. Minimal Threat Risk – maintain daily activities

3. Potential Threat – might be a threat, but unconfirmed, officially

2. Credible Threat – a threat is credible, and a WMD has been confirmed

1. Incident – An incident HAS OCCURRED!

Following a Dirty Bomb Blast…

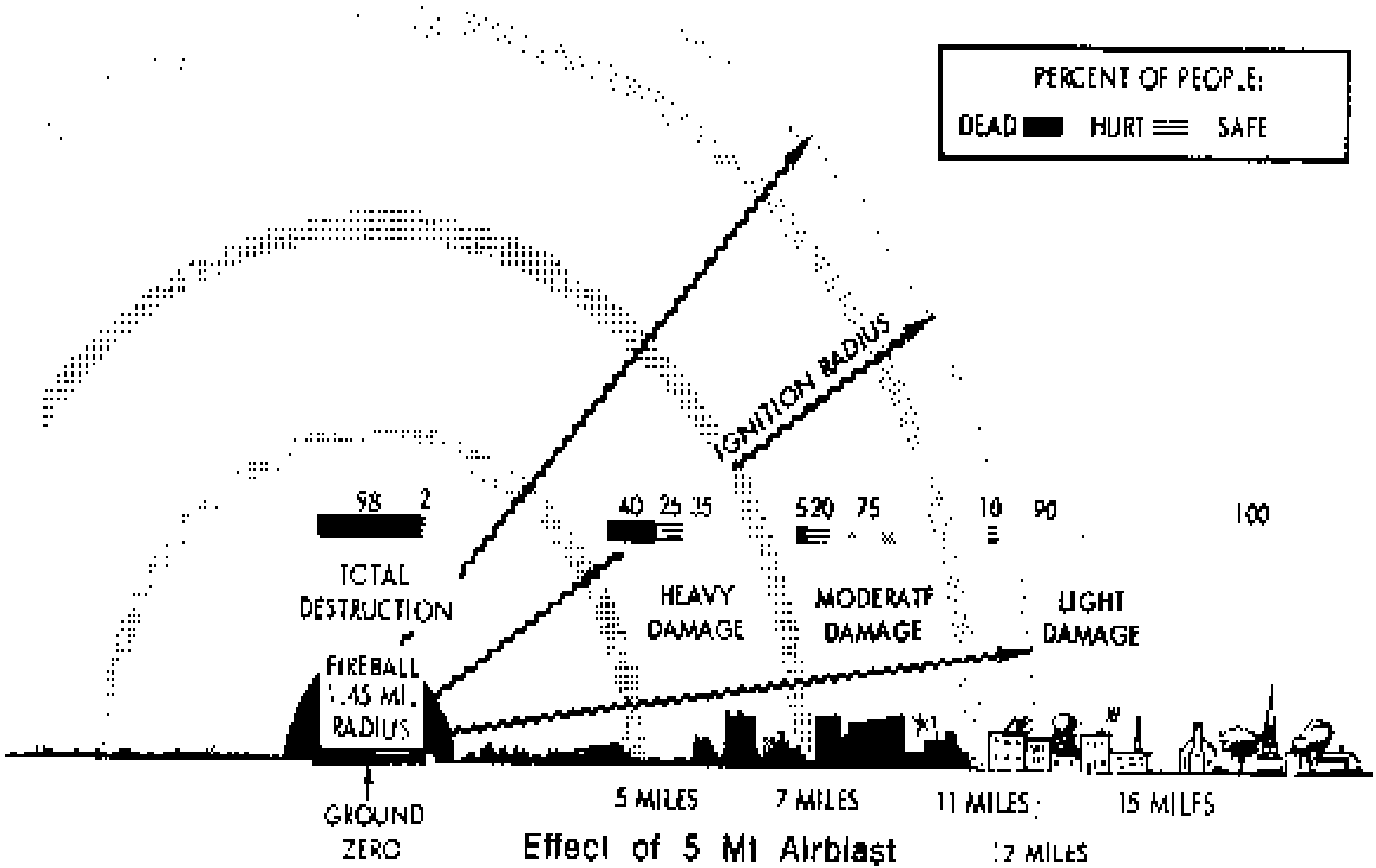
Crowd control would be next to impossible, and few people would wait around at the site to be screened for radiological contamination. They would “presumably” think about it later, and seek medical attention, probably by flooding hospital emergency rooms and doctors office phone switchboards. Some hospitals are better prepared to handle radiation accidents and emergencies than others, but the public assumes all hospitals can handle it. Some hospitals have not provided the necessary funds to get the equipment, upgrade the Emergency Room, and train staff with drills. How would you know where to take a victim? It depends on how many victims. Some well-prepared hospitals still couldn’t take adequate care of 10 or more seriously-wounded contaminated victims. Some couldn’t take care of one. Usually, PEMA or FEMA, and your central command control should know.

Hospital Preparedness

Hospitals have to determine how to screen large numbers of victims. They also have to decide when their resources are so strained that they have to close the door to any new patients, to best protect their existing patients. There is no requirement forcing hospitals to prepare for WMD. WMD funds are being made available, but how they are used are up to the hospital. There is no regulatory guidance. Hospitals should have a plan to gain access to PA BRP, NRC, FEMA, PEMA, or a national laboratory to process its radiobiological samples, if it does not have proportional counters, liquid scintillation counters, or multichannel analyzers (most all do not).

Results of a Small Nuclear Blast in a City

The shockwave air blast would send flying glass creating fatalities for 60-600 meters. There would be injuries of thermal burns from the radiation fireball creating blindness from the intense light and fatalities for 60-1800 meters. Fatalities from radiation exposure would be from 200-1200 meters initially, and after the first hour 1200-9600 meters. There would be effects from ground shock, crater, etc. This is highly improbable, as to locate such a device in a City such as New York, it would have to be transported there. It’s radiation signature should be detected.



Effect of 5 Mt Airblast

Medical Management of Radiation Casualties

Screening the type of victim will be essential, making triage decisions, deciding on how many go where, etc. will have to be decided. Stabilizing medical injuries take precedence, regardless of the contamination or exposure coming from the victim. No victim should represent a hazard to staff greater than the need to achieve their medical stability.

Recommended Categories of Casualties

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1. Externally exposed only, no contamination internal or external
2. Externally exposed and external contamination only
3. Externally exposed and internal contamination only
4. Externally exposed and internally and externally contaminated
5. Injured, not contaminated, maybe exposed
6. Injured, contaminated, maybe exposed
7. No exposure, no contamination, no injury, but psychological trauma, distressed

1. External Exposure, No Injury, No Contamination

Calm them with reassurances that they have no contamination and are being released to go home. There will be a radiological assessment "team" that try to reconstuct their probable exposure, and that that "team" will get back to them with the data within a month. Have victim answer reconstruction scenario form for "team".

2. External Exposure and External Contamination

1. Provide the reassurances of Category I following decontamination of their external contamination, including completion of radiological reconstruction scenario form.
2. Decontamination – includes showering and monitoring victim with a Geiger-counter until skin reads background radiation levels, or next best thing. Clothing may have to be retained for decay – estimate how long. Issue disposable clothing to wear home, or have companion bring fresh clothing.

3. External Exposure with Internal Contamination

1. Same as Catergory I.
2. Take nasal swabs, biological samples like urine samples or feces. Upon conclusion of radionuclide and amount of ingested to inhaled radioactivity, the physician in charge will prescribe medicine to assist with purging the toxins from the body. Following this treatment, or assessment, the patient may go home

4. External Exposure with Internal and External Contamination

Follow the procedures of Catergory 1, 2, and 3.

5. Victim Injured, but No Contamination

1. Stabilize medical condition
2. Complete radiological assessment questionnaire.
3. Release patient when stabilized

6. Victim Injured, with External Contamination

1. Stabilize medical condition
2. Proceed with protocol of Category 2
3. If victim has internal contamination, then utilize the protocol of Category 3
4. Complete radiological assessment questionnaire
5. Release patient to go home

7. Patient presents with no injuries, no contamination, and probably no exposure

1. Complete a radiological assessment questionnaire
2. Reassure the “victim” that they were very fortunate no to be effected, and dismiss them
3. If victim refuses to be psychologically stable, refer the victim to a counselor or psychiatrist

Radiological Assessment Form

Ideally, a standardized form will be generated prior to the need for it's use. In case it is not, the data to be collected at a minimum is as follows:

- Where was the victim relative to ground zero?
- How long did the victim remain at ground zero? In the same location?
- What physiological symptoms does the victim present with?
- What physical maladies does the victim present with? Were any pre-existing?
- Was the victim contaminated externally? How long? How known?
- Was the victim internally contaminated? How long? How known?
- What intervention was performed, if any?

Radiation Units

- Roentgen (R) – exposure of ionizing radiation caused by gamma or X-rays in air (can be measured directly)
- RAD – Radiation Absorbed Dose, or Gray (Gy) 100 RAD = 1 Gy (must be calculated)
- REM – Radiation Equivalent Man, unit of Dose Equivalence, or Sievert (Sv) 100 REM = 1 Sv (must be calculated)
- For Alphas: 1 RAD = 20 REM (Q.F. = 20)
- For Betas, Gammas, X-rays: 1 RAD = 1 REM (Q.F. = 1)
- For Neutrons: 1 RAD = 10 REM (Q.F. =10)
- REM = RAD x Q.F.   Q.F. = Quality Factor, which corrects for the energy absorbed by the different types of ionizing radiation
- For X-rays and Gamma Rays 1 R = 1 RAD = 1 REM approximately, so they are often used interchangeably

Prefixes of Radioactivity Units

Radioactivity Units

1 Curie (Ci) = 3.7 x 10^{10} disintegrations/sec. (d/s)

1 mCi = 3.7 x 10^{7} d/s

1 uCi = 3.7 x 10^{4} d/s

1 nCi = 37 d/s

1 pCi = 0.037 d/s or 2.2 disintegrations/min. (d/m)

1 Bequerel (Bq) = 1 d/s

37 MBq = 1 mCi (1 MBq = 1,000,000 Bq)

$300 Key Ring

Radiation Detector

Signs to be posted

A Brief Primer in Radiation Biology

Relative Radiosensitivity of Cells – from the most radiosensitive to the most radioresistent

Red Blood Cells (RBCs) → Other Blood Cells → Intestinal Villi → Skin → Muscle → Bone → Nerve

Deterministic Effects: has a threshold response to increasing radiation (cararact induction)

Stochastic Effects: has a linear increase in probability of risk (cancer induction)

Early Effects: skin-reddening (not from thermal burns), decrease in RBCs

Late Effects: cataract induction, cancers - leukemia (2-5 yrs); thyroid (4-6 yrs); solid malignant tumors (10-40 yrs.)

Radiation Biology Continued

The concept of an increased risk – especially the increase of a risk rate. For instance, if the normal risk (with only background radiation) of developing leukemia is 1 in 100,000 people, and it is known that 1 RAD of radiation will increase that risk rate by 40%, that sounds like a lot, but wait, a 40% increase in the risk rate changes the risk to 1.4 in 100,000. Now that doesn't sound so bad. One must be careful in how one reads statistics, they can be manipulated to influence you.

Radiation Exposures in Perspective

Background Radiation in Pennsylvania is 100 mREM/yr. (In Denver, CO it is 300 mREM/yr.)

A Chest X-ray = 10 mREM (to skin of chest only)

A Mammogram = 200 mREM/view

A C.T. = 3000 mREM/series (to area of interest)

A Cardiac Cath. = 100,000 mREM to skin around

the heart

The Occupational Exposure Limit = 5000 mREM/yr, total body, and 50,000 mREM/yr. to the skin

The non-occupational exposure limit, and limit for pregnant employees is 500 mREM/yr. and per 9 mo., respectively

Radiation Skin Burns

Exposures that Cause the Effects of the Radiation Sickness Syndrome

>10,000 mREM (10 REM) to a developing fetus can cause a decrease in fetal head size, and an increased risk of developing leukemia

> 25,000 mREM (25 REM) causes a decrease in WBCs

> 50,000 mREM (50 REM) causes weakness and a loss of appetite

> 100,000 mREM (100 REM) is the threshold for possible skin reddening and epilation

> 200,000 mREM (200 REM) can cause nausea, vomiting

> 300,000 to 500,000 mREM (300-500 REM) is the LD 50/30 (50% people so exposed will die in 30 days-without intervention)

> 600,000 mREM (600 REM) permanent sterility

> 1,000,000 mREM (1000 REM) (10 Sv) is the LD 100/30, without intervention, such as a stem cell bone marrow transplant

>10,000,000 mREM (10,000 REM) (100 Sv) = molecular death (instantaneous death due to the radiation intensity)

Psychological Management of Dirty Bomb Casualties

1. 1st responders – from 9/11 it was discovered that 1st responders suffered from extended work hours, seeing dead bodies-especially those of children, etc. Command control must rotate manpower to minimize this trauma.
2. Victims – Families separated, concerns of pregnant women, adults with psychological trauma and counseling needs.
3. Stigma of "being contaminated" could make returning victims be treated like "lepers" by uninformed family.
4. Problem of media mixed messages, restoration of trust, need to refer media comments to administrative chiefs.

Steven Hirsch / Corbis Sygma

A Word About SSKI

Super saturated Potassium Iodide (SSKI, or KI, for short) is useful for the prevention of radioactive iodine contamination in the air or water only. It must be given before an event to within about ½ hour following a release of radioiodine into the air. This is often a difficult task to achieve. It is not “anti-radiation medicine”. When given in adequate doses to achieve thyroid blockage, it eliminates the ability to monitor that person’s thyroid function effectively for up to a year! Some people don’t even know that they are sensitive to KI. In my humble opinion, it is a waste to distribute this or use it, even if radioiodines are present, because rarely does the media or emergency agencies give you the ½ hour notice that is required, and it has too many down sides for the minor chance of blocking some uptake.


KI4U
Thyroid Blocking Tablets
KI
EACH TABLET CONTAINS 65 MG
OF POTASSIUM IODIDE (KI)
WHICH YIELDS 50 MG. OF IODINE

Protection of 1st Responders

The National Council of Radiation Protection (NCRP) states that a suitable alarm level is > 10 mR/hr., and that areas exceeding this exposure rate not be entered without supervision, and that a 500 mREM/yr. limit apply to managed operations, but the N.C.R.P. allows up to 50,000 mREM exposure to save a life.

So how can you keep safe?

1. Breathe through a respirator, filter, or damp cloth
2. Use your best assessment of Time-Distance-Shielding
3. Wear disposable jumpuits, etc.
4. Park ambulances up-wind from ground zero.
5. Have, and know how to use, Geiger-counters and pocket dosimeters.
6. Know who is in Command and how to contact them for decisions. Understand the role of the Health Physicist, or Radiation Safety Officer from hospitals, FEMA, PEMA, and local EMA, and the resources of PA BRP and the NRC.
7. Know how to minimize getting contaminated, and know how to get decontaminated following your shift

Jason Florio / Corbis Sygma

Additional Training for EMTs

- U.S. Army Soldier Biological and Chemical Command
- Armed Forces Radiobiological Research Institute (AFRRI)
- Defense Nuclear Weapons School
- U.S.D.O.E.
- F.E.M.A. (215-931-5576)
- P.E.M.A. (717-651-2001)

It could happen again!