# The Essential Training of Disaster Medical Assistant Team on Radiological Events

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## Abstract

Nuclear and radiation events are special patterns of disasters. As the members of disaster medical assistance team (DMAT), it is still essential to have basic requirements to recognize and manage the situation although some other specialized agencies may be also involved. To treat the victims of the radiation exposure, either via nuclear detonations or via terrorism, the safety of the personnel is still the first priority. Because of possible limited equipment for detecting the severity of radiation exposure, some general rules to judge the situation by clinical evidences may be thus important. To establish such objectives, we have to emphasize the basic training for DMAT have to include the triage and management in the initial stage of radiation incidents. The most essential components include personal protection, the skills and knowledge of evacuation and sheltering, the clinical evaluation of severity, the key points on decontamination, and other modules of management. Hands-on practice, repeated tabletop drills and real field exercises are always required to accomplish the goal. On the other hand, familiarity with response plan and good inter-agency cooperation are still the crucial step to eliminate the hazards of such disasters. *(Ann Disaster Med. 2003;2:S16-S26)*

**Key words:** Radiation; Nuclear Events; Terrorism; DMAT; Disaster Response

## Introduction

Radiation incidents are among of hazardous events emergency responders might have to deal with.[1,2] Because strict requirements are used in the shipment of radioactive materials, accidental spills or releases of these substances seldom occur.[1,2] Most of emergency responders or disaster medical assist team (DMAT) members have limited experiences in dealing with such accidents. The consequence of the hazard will be expected to be serious due to lack of practice and experiences.

## Types of Radiation Incidents

There may be three general types of radiation incidents, that is, external exposure that is irradiation from a source distant or in close proximity to the body, and contamination defined as unwanted radioactive material in or on the body.[2-8]

External irradiation occurs when all or part of the body is exposed to penetrating radiation

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from an external source.[2-8] During exposure this radiation can be absorbed by the body or it can pass completely through. A similar thing occurs during an ordinary chest x-ray. Following external exposure, an individual is not radioactive and can be treated like any other patient.

The second type of radiation injury involves contamination with radioactive materials.[2-8] Contamination means that radioactive materials in the form of gases, liquids, or solids are released into the environment and contaminate people externally, internally, or both. An external surface of the body, such as the skin, can become contaminated, and if radioactive materials get inside the body through the lungs, gut, or wounds, the contaminant can become deposited internally.

The third type of radiation injury that can occur is incorporation of radioactive material.[2-8] Incorporation refers to the uptake of radioactive materials by body cells, tissues, and target organs such as bone, liver, thyroid, or kidney. In general, radioactive materials are distributed throughout the body based upon their chemical properties. Incorporation cannot occur unless contamination has occurred.

## The Role of DMAT

As described previously, the function of the Disaster Medical Assistant Team (DMAT) includes triage of victims at the disaster site, providing sophisticated medical care in austere conditions and maintaining casualty clearing or staging locations just outside the site of the disaster. The DMATs can also provide care at a reception area when the patient evacuation part is activated. Along with the training at both team level and local/national level exercises, the DMAT members provide medical care at special events and develop palns for deployment to various disasters. However, in some special disaster conditions such as radiological events, the DMAT should have more specified training and equipments. Therefore, some specialized team for different specified disaster may be developed.

In the United States, many special teams have been developed in response for weapons of mass destruction.[9] Some of them that are responsible for radiological events include AFRAT (Airforce Radiation Assessment Team) for on-site detection, identification and quantification of any ionizing radiation hazard; ARG (Accident Response Group) for technical response for nuclear emergencies; DOE (Department of Energy) for responding to nuclear terrorism and events; ERAMS (Environment Radiation Ambient Monitoring System) for measuring radioactivity and other contaminants in the environment; NEST (Nuclear Emergency Search Team) providing specialized technical expertise to resolve nuclear terrorist incidents; REACT/TS (Radiation Emergency Assistance Center/Training Site) offering a 24-hour emergency response program to support the medical management of radiation accidents, and RERT (Radiological Emergency Response Team) for environment monitoring and risk assessment.[9]

According to the present systems in Taiwan, the supervision for the radiological event is the responsibility of Atomic Energy Committee. However, if any radiological or nuclear terrorism occurs, the role of investigation should also depend on the Bureau of Investigation or National Security Bureau. The inter-cooperation between the different agen-

cies deserves to be well established at the usual time.

## Basic Training in Managing Radiological Events for General DMAT

### *Basic concepts in radiological terrorism*

To cause the threatening effects, radiological or nuclear events may be as much as biological terrorism.[1-3,10-12] In 1994 Czech police seized 4 kg of highly enriched uranium and at almost the same time German police seized more than 400 g of plutonium. Two men were seized with 1.16 kg of weapons grade uranium in Turkey in 2001. The real attacks were two recent incidents in 2001 when terrorist groups attempted to trespass Russian nuclear storage sties. There has been reported to be 175 cases of nuclear trafficking, 18 involving highly enriched uranium or plutonium since 1993 according to the International Atomic Energy Agency. Even more alarming are reports that small fully built nuclear weapons are missing from the Russian arsenal. In 1996 the Russian general Alexander Lebed claimed that 40 of these so called suitcase weapons were stolen.

In summary, the methods by terrorists were reported to stolen stale-owned weapons or weapon components, improved nuclear devices fabricated from special nuclear material, and attack on nuclear reactors / spent nuclear fuel or radiological dispersal devices. In addition, so-called "dirty bomb" that was delivered via conventional bomb has also been reported as a weapon.[1-3,10-12]

As DMAT, the first that we have to know is to recognize the possible exposure. First, every member should be alert to the manifestations of acute radiation syndrome following a predictive pattern after substantial exposure. Victims may also present individually over a longer period of time after exposure to contaminated sources hidden in the community. There may be specific syndromes of concern, especially with a 2 to 3 weeks prior history of nausea and vomiting, including thermal burn-like lesions without documented heat exposure, immunological dysfunction with secondary infections, bleeding tendency and hair loss.[2,13,14] Because the high alertness is the first important issue for such nuclear events, every member should be familiar with the details of clinical manifestations and their possible variations.

### *Understanding the exposure*

The exposure may be recognized by knowing large radiation exposures such as a nuclear bomb or catastrophic damage to a nuclear power station, or small radiation source causing intermittent exposures those are usually met in the medical or industrial facilities. The DMAT should keep in mind that the exposure to radiation may result from any combination of external source, skin contamination with radioactive materials (so-called external contamination) and internal radiation from absorbed, inhaled, or ingested radioactive material (or so-called internal contamination).[2,13,14]

### *Inter-agency cooperation*

For the members of the DMAT, the first task works include continuous medical care for the victims in the disasters. However, the specific events such as radiation / nuclear disasters must include many other specialized organizations such as Atomic Energy Committee and the Bureau of Investigation. Inter-agency cooperation should be established in the response plan at the usual

time and practiced accordingly in the event time. In Taiwan, there is still no a highly supervised departments in central government that is full responsible for most of the disaster responses, as the FEMA works in the United States. The total disaster response plan will depend upon the Executive Yuan. It may be so urgent for us to set up a well-prepared response plan which includes the inter-agency interactions for good response for such a special event.

### *Radiological protection*

The radiological protection should include respiratory protection, skin protection and body sheltering. As we know, the respiratory protection levels are classified A, B, and C, classified by the degree of protection.[2,14] Level C protection is generally sufficient where airborne particulates are the chief concern, whereas the personnel who have to invade the hot zone should be equipped with level A. There are several basic concepts for respiratory protection. Fit-tested cartridge-filtered respirators or powered-air purifying respirators should be used when available. Any respiratory protection that is designed to protect responders against chemical or biological agents will likely offer benefits in a radiation event.

The alternative method is to use ordinary surgical masks to provide good protection against inhaling particulates, and allow excellent ventilation for working at high breathing rates. If available, high efficiency particulate air (HEPA) filter masks such as the common NIOSH "N-95" mask provide even better protection. These are standard issue for health care workers who work with patients with tuberculosis and other highly contagious diseases. These masks must be fit-tested to each individual by personnel trained in the OSHA-accepted methods. Under stressful conditions, however, they may cause breathing difficulties, due to their inherently reduced air transfer.

One must always consider other, greater hazards when selecting breathing protection. If authorities suspect that particulates such as anthrax or other such bacterial agents are present, an N-95 mask is required.[2,14,15] Neither common surgical nor N-95 masks protect against gases and vapors, however. If chemical agents are suspected, level B or higher protection is required, for both the lungs and the skin. This means fitted, full-face respirators and chemical-resistant coveralls.

### *Skin protection*

Current weather conditions, as well as the environment at the event, will drive the selection of anti-contamination clothing. Normal barrier clothing and gloves give excellent personal protection against airborne particles. Disposable medical scrub suits or high-density polyethylene coveralls and hood should be used if they are available. The choice of clothing will often be driven by other more immediate hazards, such as fire, heat, or chemicals. Protection for these hazards covers any additional threat that radioactive material could pose.

As stated above, transport of the severely injured to available acute care medical facilities should not be delayed due to suspected or confirmed radiological contamination on the patient. If a critically injured but contaminated patient must be transferred immediately, make preparations for limitation of contamination at the destination facility.

### *Body protection*

Radioactive materials may contaminate the deceased. Appropriate radiation survey assistance can confirm or rule out such a situation. If a body is known or suspected to be contaminated, personnel engaged in handling of the body should be issued personal protective equipment. As stated above, it is important for responders and mortuary personnel to be aware of other, more acutely hazardous agents that may co-contaminate the remains in question. Appropriately higher levels of protection should be used as needed.[2,3,14]

### Radiation dosimetry

Two types of devices may be used.[2,14] The first type is a clip-on badge containing either film or other radiation-sensitive material (AKA a thermoluminescent dosimeter or TLD). The second type of device is a reusable electronic dosimeter, which can be read visually or by other reading devices. Some devices of this type also "chirp" like the traditional Geiger counter. Radiation protection personnel will distribute and explain how to use such devices.

### Evacuation and sheltering

Although evacuation is always the work of Urban Rescue and Search team and emergency medical technicians, the DMAT members are still usually involved in the task even the latter team be activated 6 hours after the disaster has been recognized because of the long-lasting characteristics of the radiation events. It is thereof important for DMAT members to be familiar with the methods of evacuation and sheltering.

There are three general principles that form the basis for making decisions on intervention.[2,3,14] First, all possible efforts should be made to prevent serious deterministic health effects (such as bone marrow depression and skin burns). There is no specific dose level at which intervention should be undertaken although, at levels of dose that would cause serious deterministic effects, some kind of intervention would be almost mandatory. The second principle is that the intervention should be justified in the sense that the protective measure should do more good than harm. While this may seem obvious, inappropriate actions have been taken in accidental situations to reduce dose at an extremely high social and monetary cost. The third principle is that the levels at which an intervention is introduced and at which it is later withdrawn should be optimized. After an intervention is applied (e.g., evacuation or sheltering of a population), there needs to be optimization of the action to determine the scale and duration. Costs and benefits of such actions will change over time. If people have been relocated and the radioactivity decays sufficiently, the persons may be allowed to go back home.

Population dose assessment during the early phases of accident management is at best difficult. Early decisions regarding evacuation or sheltering are challenging. Individuals within an affected geographic area can receive widely varying doses. Often it is best to recommend sheltering and showering as an initial intervention until the situation (e.g., source, meteorology) becomes clear. Initial decisions may need to be based upon field measurements. Sheltering is 10-80% effective in reducing dose depending upon the duration of exposure, building design and ventilation.[14-16] If there is a passing plume of radioactivity, sheltering may be preferable to evacuation. When sheltering, ventilation should be tuned off to reduce influx of out-

side air. Sheltering may not be appropriate if doses are projected to be very high or long in duration. Sheltering has the advantage that people have access to food, water and communications.

Evacuation is much more disruptive and expensive than sheltering. Care needs to be taken to assess the meteorology and potential changes to avoid moving people into the path of oncoming fallout. Evacuation planning needs to consider schools, hospitals, prisons, food availability, communications and housing. It should be noted that if persons are outside and there is a major release of radioiodine or radioactive particulate material, they should be instructed to make use of any possible respiratory protection such as folded wet handkerchiefs or towels. When they reach shelter, they should change clothes and if possible shower.

Individual dose assessment is usually not possible in the early phases of a terrorist event. Individual doses may only be approximated in the first few hours or days. Relatively accurate individual dose estimates may take up to a month or more and are retrospectively performed based upon physical dosimetry, accident reconstruction or biological markers and clinical examination. Intake of long-lived radionuclides poses additional problems. Doses are often calculated in terms of "committed dose". This usually refers to the dose an individual would be expected to receive from that intake over the next 50 years. While this may make sense for a young worker, it has little relevance to workers with less than an additional 50-year life expectancy. Another issue is that doses from intakes of radionuclides are often calculated on the basis of models. There may be significant individual deviations from these estimates. With significant exposures, individual information should be used. This is particularly important if there has been an intervention (such as administration of potassium iodide) that substantially affects the clearance and biological half-life of the radionuclide.

### Triage

In a radiological event, the first thing that the first responders, emergency medical technicians or DMAT members have to do is rapid triage.[2,14-16] It is necessary to assess any trauma or medical conditions prior to consideration of radiological exposure. The triage is of extreme importance in the chaos or mass casualties of an event such as terrorism. Even after triage by the first responder or emergency medical technicians, the DMAT should keep triage again and again because the patients' condition may be complicated and dynamic.

As mentioned before, the rapid triage for such cases may depend upon the symptoms. In other words, refer the cases with time to vomiting less than 4 hours to immediate evaluation and the cases with time to vomiting longer than 4 hours to delayed evaluation if no concurrent injury.[2,13-15]

### Patients decontamination

Skin or wound contamination is almost never immediately life threatening to the patient or to medical personnel. Therefore, treating conventional trauma injuries is the first priority. Decontaminate the patient only after medical stabilization.[2,3]

Ideally, emergency medical services personnel or DMAT members will decontaminate patients at the scene of an incident prior to transport. As this will not always occur, de-

contamination procedures should be part of the operational plans and procedures of all health care facilities. Removal of outer clothing and shoes can reduce contamination by as much as 90%. Assess for radiological contamination by slowly passing a radiation detector over the entire body, insuring that the same distance is maintained in subsequent surveys. Cover open wounds prior to decontamination of surrounding skin. Remove contaminated clothing and place it in marked plastic bags, moving it to a secure location within a contaminated area. Wash bare skin and hair thoroughly, and if practical, secure and appropriately dispose of the effluent.[14,15]

### *Skin decontamination*

It remains essential to decontaminate skin to decrease the risk of acute injury, lower the risk of internal contamination, and reduce the potential of contaminating medical personnel and the environment. After removing the patient's clothing, wash the patient with soap and water to emulsify and dissolve the contamination. Gentle brushing removes some contamination bound to skin protein and also a portion of the keratinized layer.[14] Because the frequency of replacement of the stratum cornea, contamination that is not removed and not absorbed by the body immediately will be shed off within several days. The decontamination should be gentle and effective enough to remove as much contamination as possible without damaging the skin. Since it may prove difficult to remove all contamination, decontaminating to two times background radiation level should suffice. If after the third attempt, this goal is not reached, and further attempts reduce the contamination by less then 10%, cease further efforts and handle the patient following standard blood borne precautions to minimize the possible spread of the contaminant. To avoid survey errors, it has to be sure that the same meter to skin distance is used in all surveys. If washing will not remove stubborn hand and distal extremity skin contamination, wrap the contaminated area, and over time, sweating will decrease contamination. To decontaminate hair, use any commercial shampoo without conditioner because the latter bind material to hair protein and make removal more difficult. Consider clipping hair to remove contaminants but avoid removing eyebrows because they may not regrow.

### *Wound decontamination*

The patterns of wound affect the absorption and decontamination of radioactive substances.[2,3,14-16] Abrasions may disrupt the skin barrier to increase absorption potential. However, they are usually easy to remove due to easily accessible contaminants. Lacerations are easy to decontaminate after the contaminated tissue is excised. Puncture wounds are difficult to decontaminate because of poor approach to the contaminants and difficulty in determining the depth and degree of contamination. Solubility, acidity/alkalinity, tissue reactivity, and particle size affect the absorption of the contaminants. Smaller particles have potential to be phagocytized and thus kept internal tissue readily.

Victims may have wounds containing radioactive materials following the detonation of a radiologic dispersal device.[2,14,16] Metallic shrapnel should be handled with forceps and, if found to be radioactive, placed in a lead container or at least six feet away from personnel. When an extremity is severely contaminated

and adequate shrapnel removal can not be allowed, amputation may be indicated. It is necessary only the injuries are so extensive with trivial functional recovery or the radiation dose is likely to result in limb necrosis as a consequence. Decisions on amputation should be delayed until long-term risks are clearly defined. Remember the phrase "decontaminate but do not mutilate".

For skin and wound decontamination, use a cleaning solution. Suggested solutions are soap and water or normal saline, povidone iodine and water, and hexachlorophene 3% detergent cleanser and water.

### *Internal decontamination treatment*

Immediate care should focus primarily on preventing internal contamination. As discussed earlier, skin or wound contamination is almost never immediately life threatening to the patient or to medical personnel. Therefore, treating conventional trauma injuries is the first priority.[2,14,16] As soon as the patient's condition permits, take steps to determine whether internal contamination has occurred. Nasal swab samples for radioactivity should be obtained as early as possible. However, under some circumstances, inhalation exposures may not yield a positive nasal swab. If contamination is present, especially in both nostrils, inhalation of a contaminant may be assumed. Collect urine and feces specimens to help determine whether internal contamination has occurred.

The reason to treat persons with internal contamination is to reduce the radiation dose from absorbed radionuclides and thus the risk of long-term biological effects (i.e., cancer). Minimize internal contamination by 1) reducing the absorption of radionuclides and their deposition in target organs, and 2) increasing excretion of the radionuclides from the body. A number of procedures are available for respiratory and gastrointestinal contamination. The benefit of removing the radioactive contaminant using modalities associated with significant side effects must be weighed against the short and long-term effects of contamination without treatment. The radioactivity and toxicity of internalized radionuclides must also be considered. Risk estimates combine professional judgment with the statistical probability of radiation-induced diseases occurring within a patient's lifetime.

According to the task force from Department of Homeland Security Working Group,[14] immediate potential treatments include:

1. Consider oral potassium iodide for those whom radioiodine is suspected as the potential contaminant.
2. Perform gastric lavage within 1-2 hours of ingestion of a single large amount till the washings are free of radioactive material.
3. Prescribe antacids (such as aluminum hydroxide and magnesium carbonate-containing formulas) as indicated to reduce gastrointestinal absorption if radionuclides are ingested. Accordingly, aluminum containing antacids are especially effective in reducing uptake of strontium and reduces uptake up to 50-85%.
4. Give cathartics to decrease distention time and radiation dose of materials in the bowel if large ingestions are suspected. It is suggested that biscodyl or phosphate soda enema will empty the colon in a few minutes. Oral agents of suppositories will take one or more hours to work and considered as second choice. Magnesium sul-

fate can be also suggested to produce insoluble sulfate compounds with some radionuclides such as radium.

5. Perform radionuclide specific therapies as guidelines.
6. Pulmonary lavage is rarely indicated and is considered only after inhalation of extreme amounts of long-lived insoluble radionuclides with the possible result of major pulmonary sequelae.

## Conclusion

Training plays an important role in DMAT development. Although a special team may be developed for specific events such as radiation or nuclear events mentioned above, the general DMAT teams are still possibly engaged in the rescue and medical care in such incidents. For a collective group that does not work together daily at the usual time and gather to work under tough circumstances at the casualties, qualified training has to be ongoing. In addition to knowing their role and the teamwork approach, hands-on practice with the basic load supply and the equipment cache provides familiarity with the rapid set-up and also allows constant check-up of those items that are in need of repair or maintenance. And these modules have also to meet the basic requirements for the possible special incidents such as radiation. This article just summarizes many literatures and provides some possible basic requirements of DMAT training for nuclear / radiation events mentioned above.

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# 災難醫療救援隊在核災方面應有的訓練

王宗倫

**摘要**

核災及放射性物質暴露，屬於特殊的災難型態。身為災難醫療救援隊的一員，即使在面對這種災難時，有其他特殊團隊參與，也必須對於這類事件的認知與處理，具有基本的認識。在治療遭受放射性物質暴露的病患(無論是核災，或是恐怖攻擊事件)，工作人員的安全仍是第一優先考量。因為在核災或放射性物質暴露的現場，可資利用的有效偵測工具可能有限，救援隊成員根據臨床証據判斷事件嚴重性的規則，將非常重要。為了達成以上目的，吾人必須強調，對於災難醫療救援隊的基礎訓練，必須包括在核災發生初期的相關檢傷分類，及臨床處置。其中最重要的部份包括：個人防護、脫困及掩蔽、嚴重度的臨床評估、去污之重點，以及其他重要相關處理步驟。實際操作練習，重複性的沙盤推演，以及實際演練，都是達到以上目標的重要關鍵。當然，整個團隊成員對於應變計劃的熟悉度，以及良好的跨單位間合作，都是減少此類災難至最低所不可或缺的要素。*(Ann Disaster Med. 2003;2:S16-S26)*

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