Radiation Injury Treatment Network® (RITN)

Concept of Operations

The purpose of this document is to establish a uniform understanding among RITN center staff and non-medical RITN partners of the anticipated participation of RITN centers during a national disaster. The Concept of Operations describes the triage and flow of casualties from the initial catastrophic incident through the disaster aftermath to the treatment facility.

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Table of Contents

1) Executive Summary
2) Situation
3) Initial Response
4) Patient Movement and Distribution
5) Patient Profile
6) RITN Activation and Casualty Management Timeline
7) References
8) Contributors

Executive Summary

This document outlines the anticipated integration of the Radiation Injury Treatment Network® (RITN) into the national response to a mass casualty incident resulting in marrow-toxic injuries. RITN centers are affiliated with the National Marrow Donor Program network of care providers, and include medical centers (academic medical centers, tertiary care centers, and cancer centers) with expertise in hematology-oncology patient management including hematopoietic cell transplantation ("marrow transplantation" for the purposes of this document), blood donor centers, and umbilical cord blood banks. These institutions are stand-alone entities that are voluntarily preparing for the response to incidents that result in marrow toxic injuries.

Bone marrow injury could result from significant exposure to either ionizing radiation or marrow suppressive chemicals such as mustard agents. Hematologists and oncologists have expertise in the management of marrow toxicity as this is a common effect of therapeutic radiation and chemotherapy. Radiological/nuclear incident casualties would likely require similar approaches to care. The primary management will be supportive care with a very limited number of marrow transplants anticipated.

Irradiated casualties will be decontaminated, stabilized and triaged prior to their arrival at RITN medical centers. The National Disaster Medical System will oversee these activities and control the distribution of patients to the Federal Coordinating Center, which will then coordinate with local public health agencies to distribute patients to the appropriate hospital. After a mass casualty incident, formal transport of patients to distant RITN centers is expected to be delayed by at least 96 hours. However, many casualties will self-evacuate and could arrive at RITN centers within the region of the incident even before the onset of symptoms.

RITN has established treatment guidelines that include the principles of ARS management, including template hospital admission orders, approaches for casualty triage and selection of candidates for HLA-typing and marrow transplantation. Finally, RITN centers will also collect patient demographic, clinical and treatment data through the standard NMDP data collection process, which will be available for future research.

Situation

The Radiation Injury Treatment Network® (RITN) prepares to receive casualties from a mass casualty incident with marrow toxic injuries[1]. There are several possible sources of mass casualty incidents that could result in marrow-toxic injuries, including: an improvised nuclear device (IND), a radiological dispersal device (RDD – a.k.a. "dirty bomb"), a radiological exposure device (RED), a catastrophic nuclear power plant accident, or exposure to a mustard agent. An incident resulting in mass casualties would most likely be the result of a terrorist attack.

The Department of Homeland Security's National Planning Scenarios[2] includes the detonation of a 10 kT (kiloton) improvised nuclear device; this is somewhat smaller than the bomb detonated over Hiroshima during World War II[3]. If a 10kT IND were detonated in a single metropolitan area, the devastation would be enormous yet manageable. The Cold War scenario of complete devastation is not applicable to a 10 kT IND. The most severe devastation from a 10 kT IND would likely be limited to a ½ mile radius from the detonation site[4] (Figure 1). However, radiation from fallout could result in doses sufficient to cause marrow toxicity for several miles from the detonation. This document will focus on a terrorist IND, as this is the most catastrophic radiation scenario and could result in 900,000 or more casualties[5], overwhelm local medical infrastructure and require the distribution of casualties nationally.

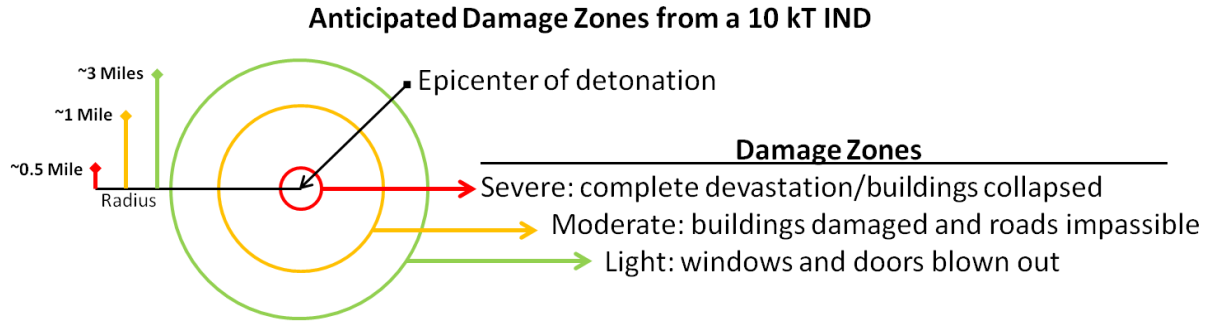

Figure 1: Adapted from Planning Guidance for Response to a Nuclear Detonation[4]

Bone marrow is the source of the human blood and immune systems. Casualties with significant marrow-toxic injuries will require supportive care to recover. Supportive care may include the application of cytokines (that boost the production of new marrow cells), transfusions as well as the administration of antibiotics to prevent or treat infection. Exposure to ionizing radiation affects bone marrow at very low doses. However, complete destruction of the human marrow system requires whole body exposure to significant doses. A person's immune system would be impacted at doses above 1 Gy. Doses between 2-6 Gy of exposure would likely be survivable with prompt intensive supportive care[6]. Above 8-10 Gy, survival is unlikely even with intensive supportive care.

It should be noted that casualties with combined injury (i.e., the combination of radiation with trauma or cutaneous burns) have a markedly worse prognosis compared to those with radiation injury alone. In a mass casualty incident, casualties with exposure to as little as 2 Gray (Gy) of radiation who also have moderate or severe trauma are unlikely to survive[6]. Thus, casualties with significant but survivable radiation injury who lack other significant injuries will be prioritized for transfer to RITN centers.

A 10kT IND would be much smaller than the average military weapon, but would nevertheless result in significant radioactive fallout being deposited as far away as 20 miles downwind (Figure 2)[5]. The total number of injured casualties and their breakdown by type and degree of injury (radiation only, trauma/burns only, or combined) could vary greatly depending on the location and type of detonation. Importantly, sheltering in place after the detonation could drastically reduce the number of potential casualties exposed to radioactive fallout.

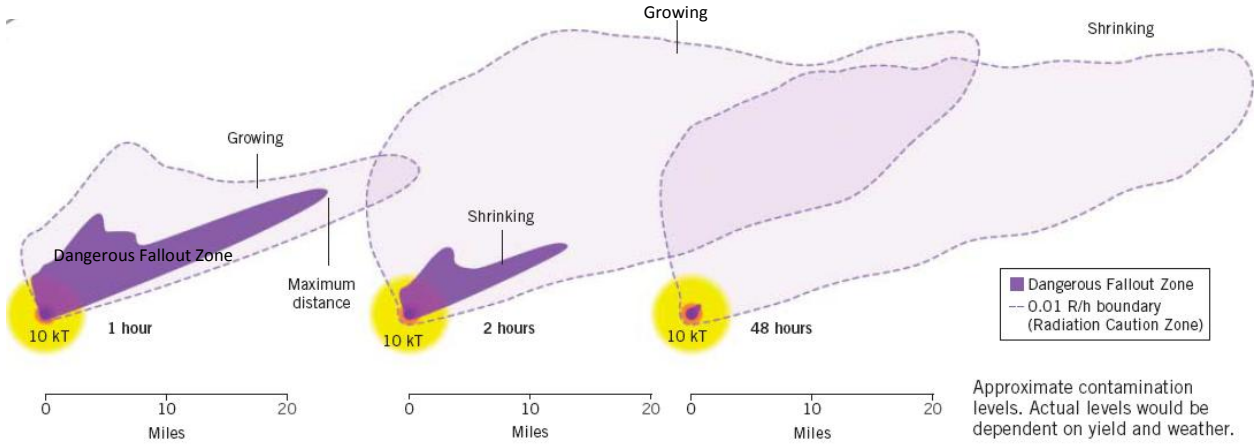

Figure 2: Illustration of the Dangerous Fallout zone from the ground burst detonation of an IND.[7] The dose in the Dangerous Fallout zone could cause marrow injury. Sheltering-in-place is key to reducing dose, as the hazard dissipates relatively quickly.

The total possible number of casualties appropriate for management at RITN centers is estimated to range between 10,000 – 63,000[7]; this is a small fraction of the total number of possible casualties, yet still overwhelming to the medical communities that would be called upon to help. As the medical community receives the surge of casualties, the number of casualties may temporarily exceed the availability of beds, staff, and specialized equipment necessary for normal standards of care. Imbalances between need and resource availability may require the implementation of Crisis Standards of Care (also called Altered Standards of Care) that typically require approval at the State level. For RITN centers to manage such a large number of casualties, patients will need to be triaged into categories roughly based on radiation injuries and delineated as: mild, moderate, severe and expectant (Table 1).

Table 1. Radiation Casualty Estimates for an Improvised Nuclear Device				
Radiation Dose (Gy)	**Care Requirement**	**Mid Casualty Estimate** (50th %tile)	**Moderately-High Casualty Estimate** (85th %tile)	**High Casualty Estimate** (95 %tile)
Mild (0.75-1.5)	Outpatient monitoring	5,000	32,000	91,000
Moderate (1.5-5.3)	Supportive Care and possible inpatient admission	7,000	29,000	51,000
Severe (5.3-8.3)	Intensive Supportive Care (most possibly including HCT)	3,000	9,000	12,000
Expectant (>8.3)	Comfort Care	10,000	28,000	47,000
Combined Injury and Radiation (>1.5)	Stabilization and monitoring, pending resource availability	3,000	20,000	44,000

Estimate of total casualties for triage to RITN (Moderate + Severe categories)	**10,000**	**38,000**	**63,000**

***Radiation doses are estimates based on clinical presentation and laboratory values.

Table 1: Adapted from Allocation of scarce resources after a nuclear detonation: setting the context[7]

These categories do not necessarily have distinct divisions as the individual patient's condition will dictate the level of care required. Many casualties will require only monitoring of blood counts as outpatients' while others will require inpatient supportive care, and an even smaller percentage of patients will require intensive approaches possibly including marrow transplantation (Figure 3).

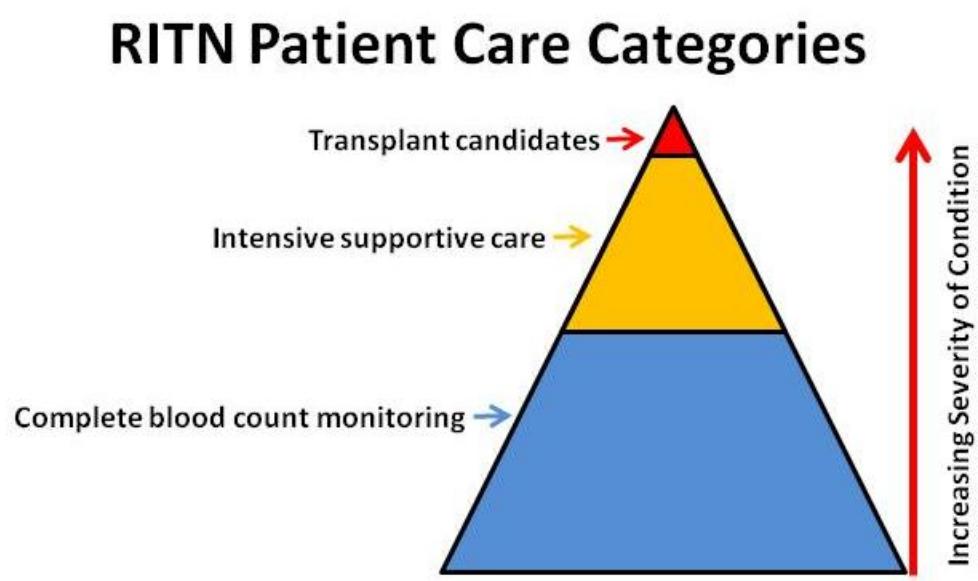

Figure 3: The composition of casualties is very difficult to estimate. This figure conveys the point that the majority of casualties will require supportive care, frequently as an outpatient.

What is critical to the ability to care for a large number of patients is the latency period that exists between exposure and the clinical manifestation of radiation injury[6]. Following a significant radiation dose (> 2 Gy), there may be a short period of symptoms followed by a latency period lasting up to 3 weeks before there is a substantial decline in peripheral blood neutrophils and platelets. The early use of bone marrow cytokines can potentially mitigate the neutrophil depression and the risk of infection[6]. Just as blood cell counts are monitored in the outpatient setting routinely in oncology care, so too could this approach be used after a nuclear detonation. Consequently, many radiation casualties may only need to be sent to a center where they would be monitored as outpatients. If their condition worsened, they would be admitted to the hospital until they could be discharged and again followed as outpatients.

Initial Response

All disaster responses begin locally and are expanded beyond local resources as those local capabilities are exceeded. Local jurisdictions will rely on mutual aid to meet the initial response needs, by calling on regional assets for assistance from adjacent counties or states. These regional resources will help bridge the gap until federal resources arrive to support the response. Federal assets will likely be immediately placed on alert and prepare to bring available assets to assist in the response. While initial supply, distribution and response may begin within 24 hours, it will take days for significant federal resources to arrive on scene.

After the detonation of an IND, casualties will begin to self evacuate away from the detonation site. Authorities will advise the public within areas containing radioactive fallout to shelter in place for 12-48 hours, depending on the site. Ad hoc first aid sites are expected to begin to form wherever there is space available, as people make their way from the epicenter. These sites could be parking lots, fields, parks, office buildings, warehouses, etc. The sites most likely will not have the resources to provide much in the form of first aid other than a place to rest and information on where medical aid may be available. Further out, yet as close as safely possible, first responders will begin to establish medical aid stations to provide medical aid, conduct radiological survey and decontaminate (if equipped) and to assist with evacuations. The next tier will be casualty collection centers established by state or local public health authorities, which should be capable of collecting, triaging and decontaminating casualties, while also providing medical treatment and evacuation to the appropriate sites for specialized medical care (Figure 4).

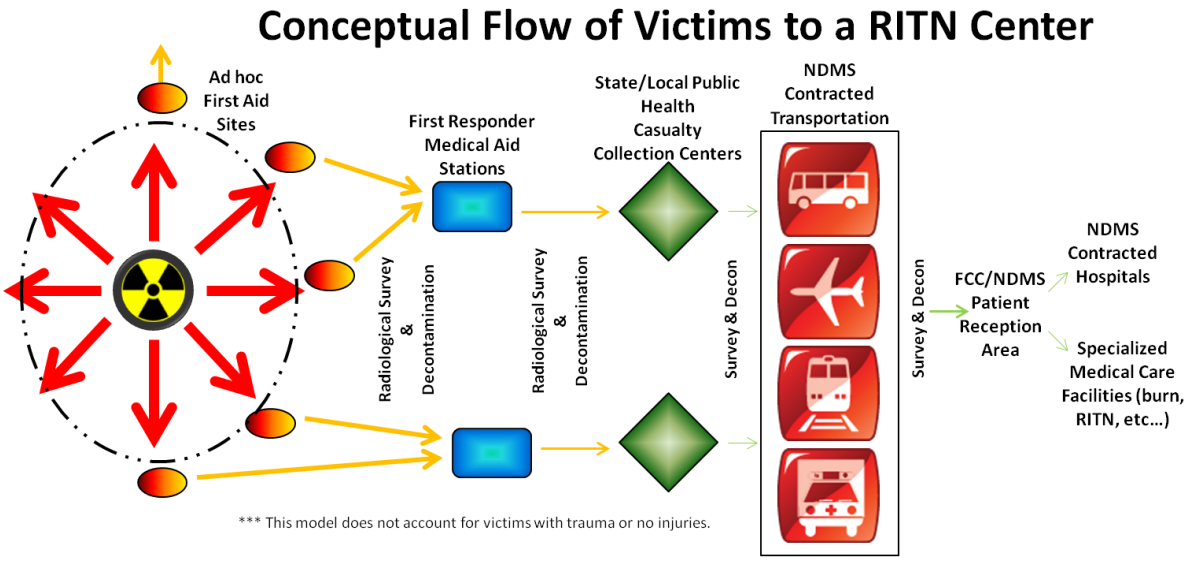

Figure 4: Illustration of the flow of casualties to a RITN center following a nuclear detonation[7, 8, 9]. RITN centers may happen to be a local medical care facility, but in general RITN is a network of distant expert care centers.

The provision of medical care during a national disaster, including the evacuation of patients, is the responsibility of the state, local, regional and tribal governments. Assistance can be requested from the Department of Health and Human Services - Assistant Secretary for Preparedness and Response (DHHS-ASPR). ASPR will notify the NMDP of the need to activate RITN[10]. Once alerted by ASPR, the RITN Control Cell at the NMDP would notify RITN centers of the possibility of patients being distributed to their hospitals. This would be accomplished through email if the Internet is functioning. Facsimile notification would be used if the Internet is overwhelmed, along with individual calls via a landline/cellular telephones. Satellite telephones would be the last resort of communication. Within 12 hours of notification, RITN centers would be expected to submit a RITN Capabilities Report that summarizes the “Current” and “Next 24 Hour” status of their staff and available resources. The RITN Control Cell would consolidate and provide this information to ASPR to assist with the planning for distribution of patients to the appropriate center(s) for care.

Patient Movement and Distribution

At casualty collection centers, casualties will be surveyed for contamination, decontaminated if necessary, triaged for medical care and prioritized for medical evacuation, if applicable. These casualty collection centers will be scattered around the disaster area (outside the harmful radiation zone) to provide medical evaluation and treatment to as many casualties as possible (Figure 4). If a casualty is prioritized for evacuation, he/she will be transported to an appropriate hospital for care through the National Disaster Medical System (NDMS).

The NDMS includes over 1,000 hospitals that have formally agreed to provide care for disaster casualties. These hospitals are guaranteed to be reimbursed at 110% of the Centers for Medicare and Medicaid Services (CMS) rate for patients distributed through NDMS[9] for the first 30 days of inpatient care. The hospitals must first seek reimbursement from patients' third party insurers, if applicable.

NDMS has multiple resources available to distribute patients, ranging from ambulances to aircraft. Based on the location of RITN centers around the nation, transport to RITN centers will likely utilize aircraft. According to current planning, patient distribution by aircraft will be limited initially to distances of no more than 200 miles to reduce the flight time and thereby allow for more round trips and less exposure to high altitudes, which could worsen some conditions[11]. All patients will be stabilized before transport. However, as medical conditions could deteriorate during transport, only a few of the patients on each load will be of the most critical nature. The patient mix will be controlled to limit overwhelming the small medical crew on the aircraft, which will considerably reduce the possibility of a major surge of critical patients arriving simultaneously at any receiving hospital.

Aircraft will fly to one of 72 NDMS Federal Coordinating Centers (FCC), which will then distribute the patients to their final destination for care[9] (Figure 4). FCCs may be co-located with Community Reception Centers operated by state public health departments. Receiving hospitals are required to provide periodic patient updates to the FCC. Once care is complete and the patient is discharged, it is the responsibility of the FCC to return the casualties home.

Patient Profile

Patients distributed through the National Disaster Medical System will be medically stabilized and at a minimum grossly decontaminated before transportation. Combined injury (i.e., radiation with moderate or severe trauma and/or significant burns) negatively impacts prognosis. Thus, the vast majority of casualties that receive more than 2 Gy of radiation and have significant trauma and/or burns will not be candidates for treatment by RITN centers[12].

The removal of clothing alone can reduce external contamination by radioactive fallout and other material by over 90% [13, 14, 15]. Internal contamination by ingestion or inhalation is not expected to be common after an IND detonation, but would require the use of decorporation agents (more information at www.remm.nlm.gov). Receiving institutions should conduct radiological surveys of patients before admitting them for care, although patients transported by NDMS should have already been decontaminated. This will alleviate staff concerns of potential exposure to radiation and identify any decontamination needs. Of note, medical staff responding to the 1986 Chernobyl nuclear power plant incident received on average a dose less than 0.001 Gy[13] or the equivalent of less than ½ of a chest x-ray[16].

Patients distributed to RITN centers will likely have been exposed to whole-body doses of 2-8 Gy and be experiencing signs and symptoms of Acute Radiation Syndrome (ARS)[17], such as:

- Nausea
- Vomiting
- Anorexia
- Reduced number of white blood cells (lymphocytes & granulocytes)
- Reduced number of platelets
- Erythema of the skin
- Itching or altered sensation in the skin
- Swelling and edema
- Diarrhea
- Fatigue

The RITN Acute Radiation Syndrome Treatment Guidelines[18] outline the principles of ARS management, crisis standards of care, ARS symptoms, and casualty triage. A template for hospital admission orders for radiation casualties can be found on the Radiation Emergency Medical Management website[19]. There are established algorithms[6] for prioritizing casualties to receive marrow growth factors (e.g., G-CSF) and other supportive care as well as consideration of the extent of injuries, availability of resources and current standards of care.

Methods for estimating the dose of radiation received by a casualty (known as 'biodosimetry') include serial blood counts and chromosome assays, and may be available to help stratify casualties. Growth factors and antibiotics are widely utilized at RITN centers and additional supplies may be available through the Strategic National Stockpile, a federal stockpile of emergency equipment, medicine and medical consumables. Finally, RITN centers will collect patient data for all casualties after the event. This data will be formatted and submitted using the standard NMDP online data collection process and then made available to researchers both inside and outside the NMDP.

RITN Activation and Casualty Management Timeline (estimated)

Action	Responsible Party	Time From Incident
Incident occurs		
RITN Control Cell notified to activate RITN	ASPR	0 hour
RITN centers notified of incident via email	RITN Control Cell	<2 hrs
Capabilities Review		
Review staff availability	RITN center	<14 hrs
Review current & pending patient activity		
Review available resources (equipment, medical consumables and medications)		
Submit Capabilities Report		
Ad hoc First Aide Site		
Casualties self evacuate to ad hoc first aide site	Casualties	First 48 hrs
Casualties receive buddy aid		
Direct to nearest medical aid station		
Medical Aid Station		
Triage	First responders	First 96 hrs
Radiological survey and decontamination (if capable)		
Provide medical aid		
Refer and evacuate to casualty collection center		
Casualty Collection Center		
Triage	State/Local Public Health (PH)	1-7 days
Radiological survey and decontamination		
Provide medical treatment		
Identification of casualties for specialized care		
Refer and evacuate to distribution hub		
Medical Evacuation		
Transportation to receiving distribution site	NDMS	2-14 days
Triage	Federal Coordinating Center (FCC), NDMS Patient Reception Area, State/Local PH	
Radiological survey and decontamination		
Casualty receipt and medical care assessment		
Notification of distribution plan to hospitals		
Transportation of casualty to hospital		
Definitive Medical Care		
Triage	RITN center	2 - >30 days
Radiological survey and decontamination		
Admit or observe as outpatient		
Provide ongoing assessment and treatment		
Report patient condition to FCC		
Complete treatment		
Transportation of patients to home of record	Local PH/FCC/NDMS	

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