# 2012 RITN Tabletop Exercise

**Contents (9 pages total):**



## Deadline for submission of answers to exercise questions is September 30, 2012

**Please distribute this packet in its entirety to all exercise participants.**

# Reference

Encourage members of the response team to review the following before the exercise:

Radiation Injury Treatment Network Concept of Operations:
http://ritn.net/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=2147483905

RITN ARS Treatment guidelines:
http://ritn.net/WorkArea/DownloadAsset.aspx?id=2147483696

**MEMORANDUM**

**TO:** Members of the Radiation Injury Treatment Network

**FROM:** [redacted]

**DATE:** February 15, 2012

**SUBJECT:** Radiation Injury Treatment Network 2012 Tabletop Exercise

Attached you will find the tabletop exercise, which is one of the required Radiation Injury Treatment Network (RITN) tasks.

Please review the scenario and answer the applicable questions enclosed to the best of your ability. Answers will only be accepted when submitted through the Internet link no later than **September 30, 2012**. Only one person should submit answers for each RITN center. Some questions may be repeated from previous exercises, please determine the current answer. The web link for answer submission is:

[redacted]

This exercise presents a scenario that would likely involve RITN. This exercise should be completed with a group of appropriate staff members. The intent of this exercise is to stimulate communication through a low stress discussion of the scenario with your staff and critical partners.

This group of staff should plan to meet for approximately two hours to review operational plans and determine the best possible answers to the questions. Each participant should review a copy of the standard operating procedures (SOPs) at his/her centers germane to RITN prior to participating in the exercise. SOPs related to RITN should be scrutinized for applicable updates and improvements.

Examples of possible participants include but are not limited to:

**Transplant Center:**

- Medical director
- Additional physicians
- Primary coordinator
- RITN point-of-contact (POC)
- Nurse leader
- Admission process representative
- Administrator/hospital executive
- Emergency management staff
- Pharmacy staff member
- Health Physicist/Radiation Safety Officer
- Representative from Social Services
- Representative from Psychiatry/Psychology
- Blood center representative
- Hospital Emergency Department Representative
- VA Representative
- NDMS Representative
- Public Health Representative
- County Emergency Manager
- Quality Representative
- Regulatory Representative
- Infectious Disease Specialist
- Cell Processing Lab Representative
- Environmental Health and Safety Rep.
- Other staff or partners

A panel that includes all of the above examples would be the "dream team" of exercise participants. Do what is reasonable for your center.

This scenario may not have all the information that you feel is necessary to provide a fully informed response. As with most emergency situations, decisions must be made with less than complete information. Therefore, please attempt to formulate your responses based on the information provided. If you have questions, please feel free to contact the RITN Control Team at ritn@nmdp.org or (612) 884-8276. Thank you for your time and participation in this critical national response initiative.

# Scenario

**Purpose:**
This scenario outlines the anticipated integration of RITN into the national response to a mass casualty incident resulting in marrow toxic injuries.

**Incident:**
Seven days ago unknown subjects detonated a one-kiloton improvised nuclear device in a large US city 500 miles away from your center. The explosion and fallout resulted in thousands of casualties with marrow toxic injuries. Although the National Disaster Medical System typically plans to keep patients within 200 miles of an incident, the number of casualties from this incident required greater distances to find enough care facilities.

**Events following incident:**
RITN was activated and directed to prepare to receive irradiated patients for evaluation and possible care. Seven days after the detonation your community received one hundred patients through the National Disaster Medical System. The Veterans Administration Emergency Manager established the Federal Coordinating Center Patient Reception Area at the local airport. Incoming patients arrived by plane and were immediately surveyed for contamination and decontaminated as needed. However, it is possible that some transferred casualties will have low levels of contamination through ingestion, inhalation or subcutaneous imbedding of radioactive material.

Upon arrival at the FCC Patient Reception Area, a blood count and cursory history and physical was performed on each casualty. Your hospital has been contacted to receive casualties from the Patient Reception Area. Your hospital-wide census is currently near 100%. After reducing the bed census as much as possible, the following staffed beds are available for use:

3 BMT ward beds: single occupancy, HEPA-filtered airflow
2 Hem/Onc ward beds: single rooms, positive pressure airflow
4 Med/Surg beds: multiple occupancy, circulated airflow
4 PACU beds: beds in an open ward with monitoring equipment but not in a designated room

The Patient Reception Area has asked you to assume care of 20 adult casualties and/or 20 pediatric casualties, depending on the types of patients treated at your center. They have provided minimal information on each casualty, including that day's WBC count and aspects of history and physical. The exercise will ask you to decide which casualties are assigned to each bed, assuming the remainder will be managed as outpatients or remain in the emergency ward until beds become available. None of the casualties require immediate transfer to an intensive care unit.

After a real incident, the amount of information (exposure dose, additional injuries, comorbidities) available for each casualty may be extremely limited. The point of this exercise is to stimulate discussion about how casualties can be triaged based on limited information and to inspire new approaches at each center for streamlining and improving the triage process.

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## Exercise Questions

**(submit online via: [redacted]**

Contact information of person submitting answers to RITN:

1. Name

   Email

   Phone

2. Select your RITN transplant center.

3. How many people participated in your exercise (keep a list of all who participated by name)?

4. Identify all members of your incident response team (Select all that apply).

   a. Medical director
   b. Additional physicians
   c. Primary coordinator
   d. RITN point-of-contact (POC)
   e. Nurse leader
   f. Admission process representative
   g. Administrator/hospital executive
   h. Emergency management staff
   i. Pharmacy staff member
   j. Radiation Safety Officer/Health Physicist
   k. Representative from Social Services
   l. Representative from Psychiatry/Psychology
   m. Blood center representative
   n. Hospital Emergency Department representative
   o. VA Representative
   p. NDMS Representative
   q. Public Health Representative
   r. County/City/State Emergency Manager
   s. Quality Representative
   t. Regulatory Representative
   u. Infectious Disease Specialist
   v. Cell Processing Lab Representative
   w. Environmental Health and Safety Representative
   x. Emergency Department Staff
   y. Other staff or partners (Please list in the block below)

5. RITN centers will likely receive patients through NDMS for specialized care. NDMS authorizes reimbursement at 110% of CMS (unless reimbursed by primary payers). RITN provides no direct payment for patient care. Is your hospital currently contracted with NDMS?

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6. How many doses of G-CSF (multiple of 300mcg) are available in your pharmacy today?

7. How will casualties be transported from the National Disaster Medical System Federal Coordinating Center Patient Reception Area to the RITN center? If you are unsure, a VA Emergency Manager could provide this information. Outline how this information was obtained for the exercise.

8. How would bed availability at your center be reported to the FCC Patient Reception Area?

9. Explain the process for conducting radiological surveys at your center to confirm that accepted casualties are adequately decontaminated?

10. Do you have a system for designating a casualty as adequately decontaminated (e.g. a designated mark/symbol/color in the chart or on their person)? If so, explain.

11. Does your RITN center care for pediatric patients, adult patients or both?

12. What is the acceptable age range for pediatric HSCT patients at your center?

13. What is the acceptable age range for adult HSCT patients at your center?

<u>For the following section, refer to the patient table(s) appropriate to your center type. If your center cares for adult and pediatric patients, complete the exercise twice (once for adults and once for children).</u>

14. Of the 20 patients, which three would be admitted to the BMT ward beds?

15. Of the 20 patients, which two would be admitted to the Hem/Onc ward beds?

16. Of the 20 patients, which four would be admitted to the Med/Surg beds?

17. Of the 20 patients, which four would be admitted to the PACU bed?

18. Which patients would be treated as outpatients (assume that family members/care providers are present)?

19. Which patients would remain in the emergency ward (e.g. on hallway stretchers)?

20. Which patients would be designated to receive only comfort care?

21. How would you decide whether a patient should receive only irradiated and leukoreduced blood products?

22. Assuming that unlimited supplies of myeloid cytokines are available, which patients would begin treatment with myeloid cytokines immediately?

23. Which patients would be HLA-typed immediately?

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24. What is your standard RN to patient ratio?

25. If crisis standards of care (formerly altered standards of care) are required and approved, is there a maximum defined RN to patient ratio at your center?

26. Discuss how your approach to triage would change if the number of casualties transferred to your center was 100 (rather than 20) and had a similar distribution of injuries and comorbidities.

27. How, if at all, will your center incorporate lessons learned from this exercise to clarify or improve current processes or procedures?

28. On a scale on 1 to 5, how would your center rate the usefulness of the annual RITN TTX (where 1=very little and 5=fantastic)?

29. Comments (free text)

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## ADULT PATIENTS

*Doses were estimated based on the casualty's location after the detonation and lymphocyte count within first 48 hours and may be incorrect.

| Patient ID | Estimated dose* | Age | Comorbidities | Signs and symptoms | Additional injuries/issues | Day 7 PMNs |
|---|---|---|---|---|---|---|
| 001 | 3 Gy | 20 | None | None | None | 1.4 |
| 002 | 3 Gy | 40 | Depression | Nausea, diarrhea | None | 0.8 |
| 003 | 3 Gy | 60 | Diabetes | None | None | 1.1 |
| 004 | 3 Gy | 80 | Coronary disease, CLL | Fatigue | Closed fracture of humerus | 2.0 |
| 005 | 4 Gy | 20 | None | Fever, nausea | None | 0.6 |
| 006 | 4 Gy | 20 | Down syndrome | None | Multiple lacerations | 0.1 |
| 007 | 4 Gy | 40 | Lupus | Diarrhea, intractable vomiting | None | 1.0 |
| 008 | 4 Gy | 40 | None | None | 5% BSA 2nd degree burn | 0.8 |
| 009 | 4 Gy | 40 | None | Fever | Traumatic eye injury | 0.2 |
| 010 | 4 Gy | 60 | Stage IV breast cancer | None | None | 0.2 |
| 011 | 4 Gy | 60 | ESRF on dialysis | Diarrhea | None | 0.8 |
| 012 | 4 Gy | 60 | Hepatitis C | Fever, hypotension, diarrhea | 10% BSA 1st degree burn | 0.2 |
| 013 | 4 Gy | 80 | HTN | Fever | Resolving flash blindness | 0.2 |
| 014 | 4 Gy | 80 | Early dementia, coronary disease, prostate cancer | Cough, rhinorrhea | Viral URI | 0.2 |
| 015 | 6 Gy | 40 | Methadone addiction | Fever, anorexia, diarrhea | 20% BSA 1st degree burn | 0.1 |
| 016 | 6 Gy | 40 | Ulcerative colitis | Fever, diarrhea | None | 0.9 |
| 017 | 8 Gy | 40 | None | Fever, lethargy | DIC, splenic infarcts | 0.0 |
| 018 | 8 Gy | 60 | Stroke with hemiparesis | Fever, obtundation, hypotension | 20% BSA 2nd degree burn | 0.0 |
| 019 | 10 Gy | 40 | Asthma | Fever, cough, dyspnea | Multilobar pneumonia | 0.0 |
| 020 | 10 Gy | 60 | Diabetes, HTN, baseline creatinine 2.1 | Fever, hypotension, diarrhea | Mucositis | 0.0 |

Abbreviations: CLL, chronic lymphocytic leukemia; BSA, body surface area; ESRF, end-stage renal failure; DIC, disseminate intravascular coagulation; HTN, hypertension; URI, upper respiratory infection; PMNs, polymorphonuclear leukocytes

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## PEDIATRIC PATIENTS

*Doses were estimated based on location after the detonation and lymphocyte count within first 48 hours and may be incorrect.

| Patient ID | Estimated dose* | Age | Comorbidities | Signs and symptoms | Additional injuries/issues | Day 7 PMNs |
|---|---|---|---|---|---|---|
| 021 | 3 Gy | 2 | None | None | None | 1.4 |
| 022 | 3 Gy | 4 | None | Nausea, diarrhea | None | 0.8 |
| 023 | 3 Gy | 12 | JRA on MTX | None | None | 1.1 |
| 024 | 3 Gy | 14 | Diabetes | Fatigue | Closed fracture of humerus | 2.0 |
| 025 | 4 Gy | 8 | None | Fever, nausea | None | 0.6 |
| 026 | 4 Gy | 5 | Down syndrome | None | Multiple lacerations | 0.1 |
| 027 | 4 Gy | 4 | Asthma | Diarrhea, $O_2$ Sat 93% | None | 1.0 |
| 028 | 4 Gy | 2 | Thalassemia trait | None | 5% BSA 2nd degree burn | 0.8 |
| 029 | 4 Gy | 1 | None | Fever | Traumatic eye injury | 0.2 |
| 030 | 4 Gy | 7 | ALL on 6-MP | None | None | 0.2 |
| 031 | 4 Gy | 9 | URI | Diarrhea | None | 0.8 |
| 032 | 4 Gy | 4 | Chronic hepatitis B | Fever, hypotension, diarrhea | 10% BSA 1st degree burn | 0.2 |
| 033 | 4 Gy | 2 | None | Fever | Resolving flash blindness | 0.2 |
| 034 | 4 Gy | 13 | Osteosarcoma 2 years in remission | Cough, rhinorrhea | Viral URI | 0.2 |
| 035 | 6 Gy | 14 | URI | Fever, anorexia, diarrhea | 20% BSA 1st degree burn | 0.1 |
| 036 | 6 Gy | 1 | None | Fever, diarrhea | None | 0.9 |
| 037 | 8 Gy | 8 | ADD | Fever, lethargy | Splenic contusion, low-grade DIC | 0.0 |
| 038 | 8 Gy | 8 | Asthma | Fever, obtundation, hypotension | 20% BSA 2nd degree burn | 0.0 |
| 039 | 10 Gy | 3 | None | Fever, cough, dyspnea | Multilobar pneumonia | 0.0 |
| 040 | 10 Gy | 17 | Sickle cell anemia | Fever, hypotension, diarrhea | Mucositis | 0.0 |

Abbreviations: ALL, acute lymphoblastic leukemia; JRA, juvenile rheumatoid arthritis; MTX, methotrexate; BSA, body surface area;; URI, upper respiratory infection; PMNs, polymorphonuclear leukocytes; ADD, attention deficit disorder

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# 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.

February 2012

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## 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.

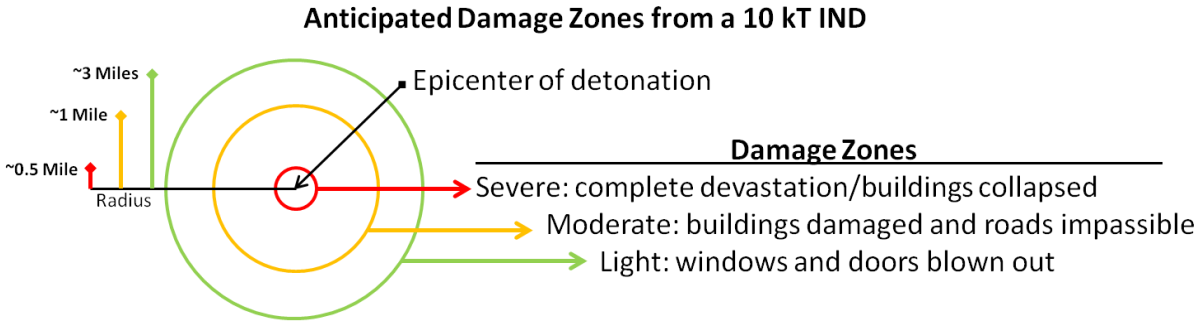


Figure 1: Adapted from Planning Guidance for Response to a Nuclear Detonation[4]

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.

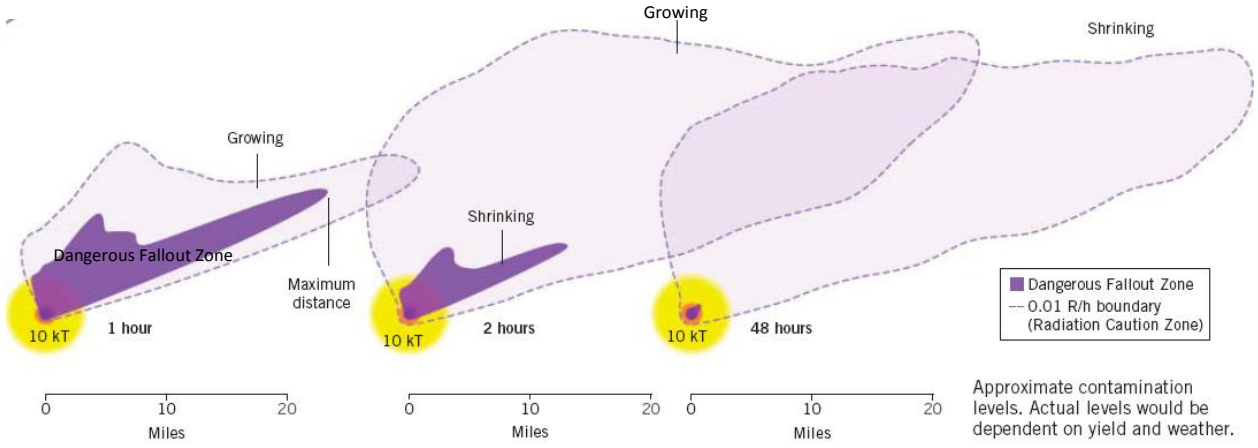


Figure 2: Illustration of the Dangerous Fallout zone from the ground burst detonation of an IND.[7] The dose in the Dangerous Fallout zone could cause marrow injury. Sheltering-in-place is key to reducing dose, as the hazard dissipates relatively quickly.

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** ($50^{th}$ %tile) | **Moderately-High Casualty Estimate** ($85^{th}$ %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).

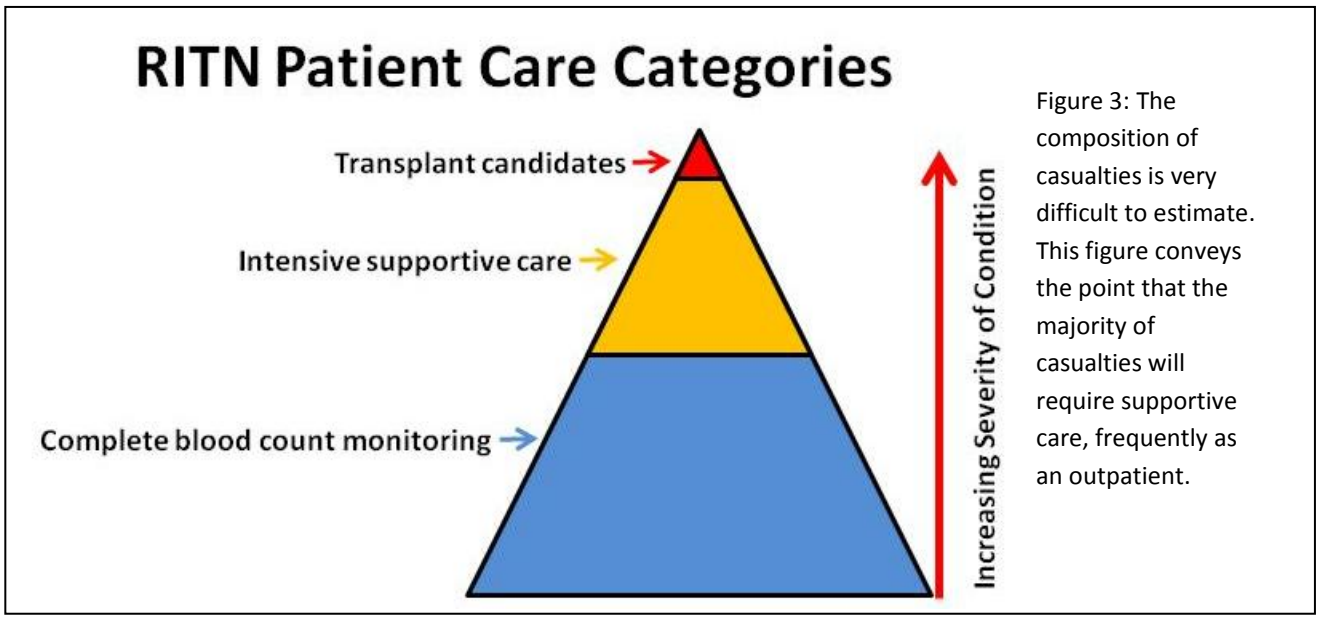


Figure 3: The composition of casualties is very difficult to estimate. This figure conveys the point that the majority of casualties will require supportive care, frequently as an outpatient.

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).

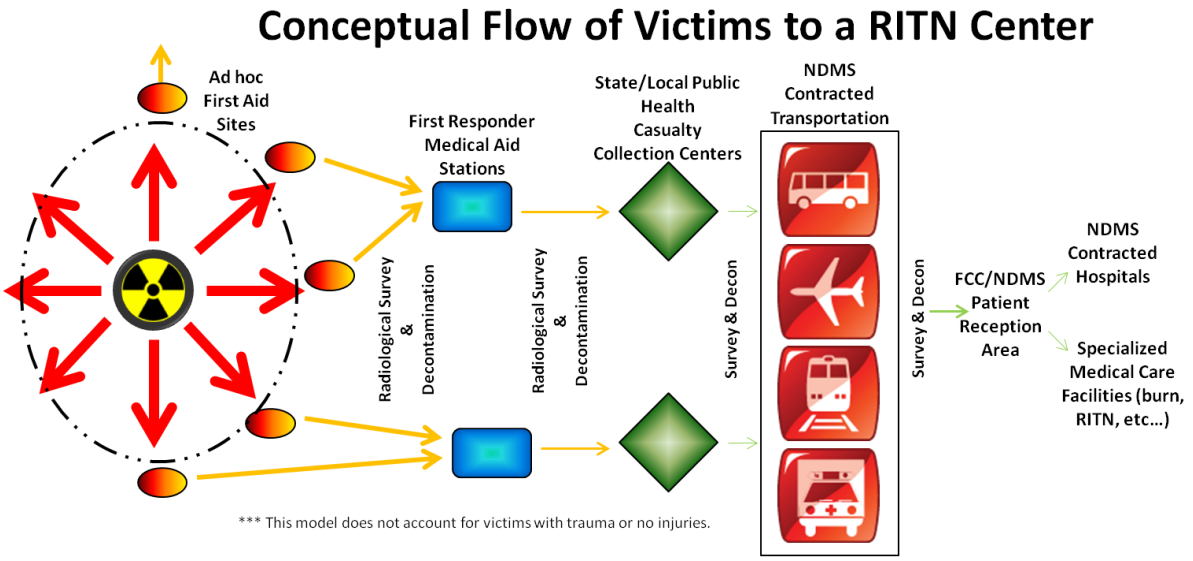


Figure 4: Illustration of the flow of casualties to a RITN center following a nuclear detonation[7, 8, 9]. RITN centers may happen to be a local medical care facility, but in general RITN is a network of distant expert care centers.

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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## Contributors

The Executive Committee of the Radiation Injury Treatment Network would like to recognize the contributions of the following people in the development of this document.

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# Acute Radiation Syndrome Treatment Guidelines

September 2010

Please forward comments or suggestions to [redacted]

# Principles of ARS management at RITN centers (1)

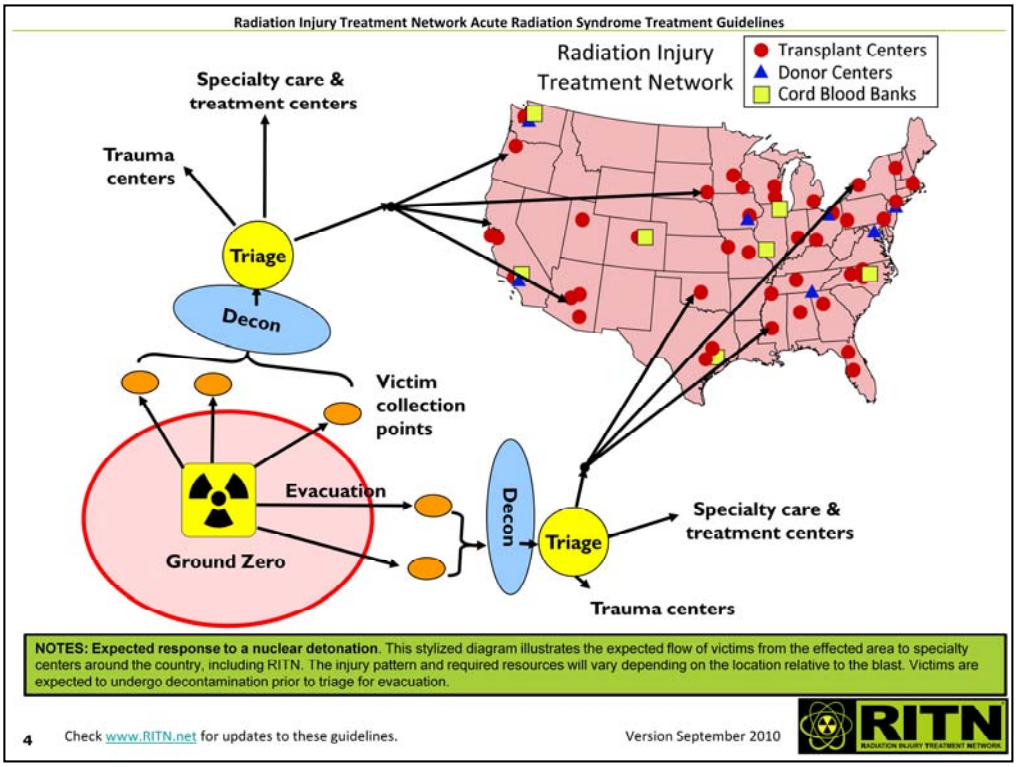
1) After a nuclear detonation, RITN and other cancer/blood and marrow transplant (BMT) centers may receive large numbers of irradiated victims, especially those with little or no trauma or burns
2) The goal of pre-event planning and post-event management is to maintain a "*functional equivalent*" of routine care for both victims and existing patients
3) Biodosimetry can predict prognosis and need for treatment
4) Prioritization for myeloid cytokines (*e.g.* G-CSF) and other key resources may be necessary due to limited supply
5) Patient tracking and family re-unification will be key objectives
6) Many evacuated patients will not require hospitalization, and thus outpatient facilities for housing and care will be required
7) Current planning includes patient decontamination prior to transfer to RITN centers. However, RITN centers should have plans to confirm adequate decontamination upon transfer.

# Principles of ARS management at RITN centers (2)

If adequate resources are available, management of victims with ARS should utilize the same approaches and decision points as for patients with cancer receiving myelosuppressive therapy, including:

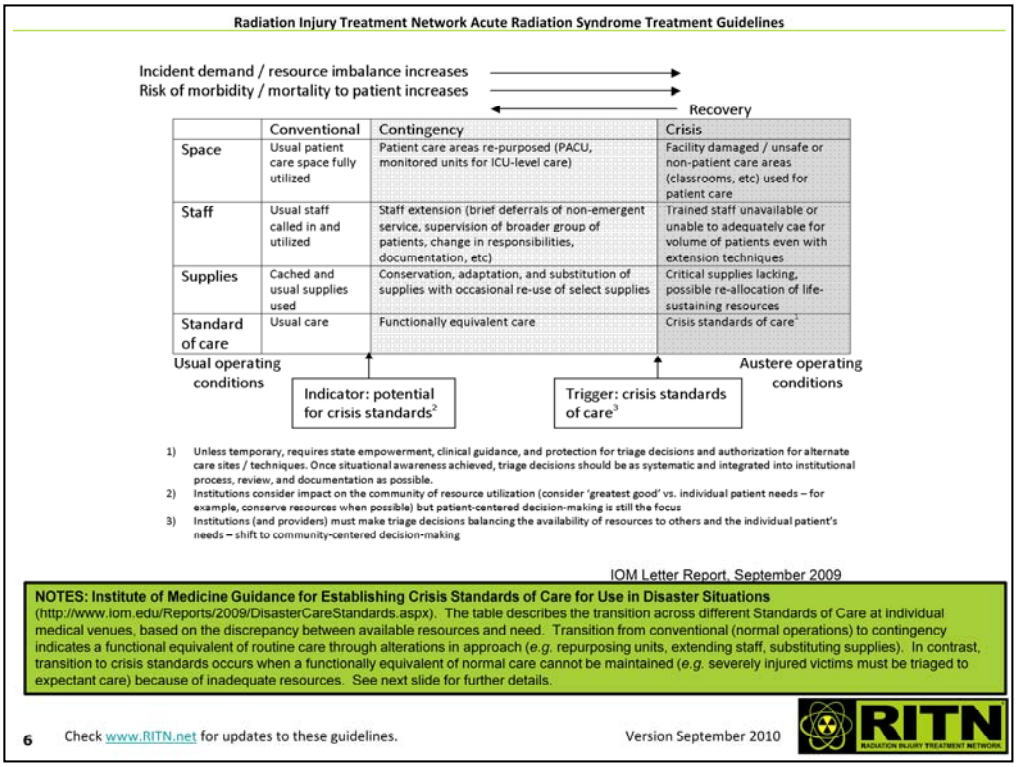
1) Hospitalization, if necessary
2) Prophylactic antibiotics and myeloid cytokines
3) Central venous access
4) Management of emesis, gastrointestinal toxicity and nutrition
5) Reverse isolation and dietary restrictions
6) Irradiated and leukocyte-depleted transfusions
7) Pediatric care

Guidance on additional radiation-related issues, including internal decontamination, biodosimetry, template admission orders and event response are available at: www.remm.nlm.gov.

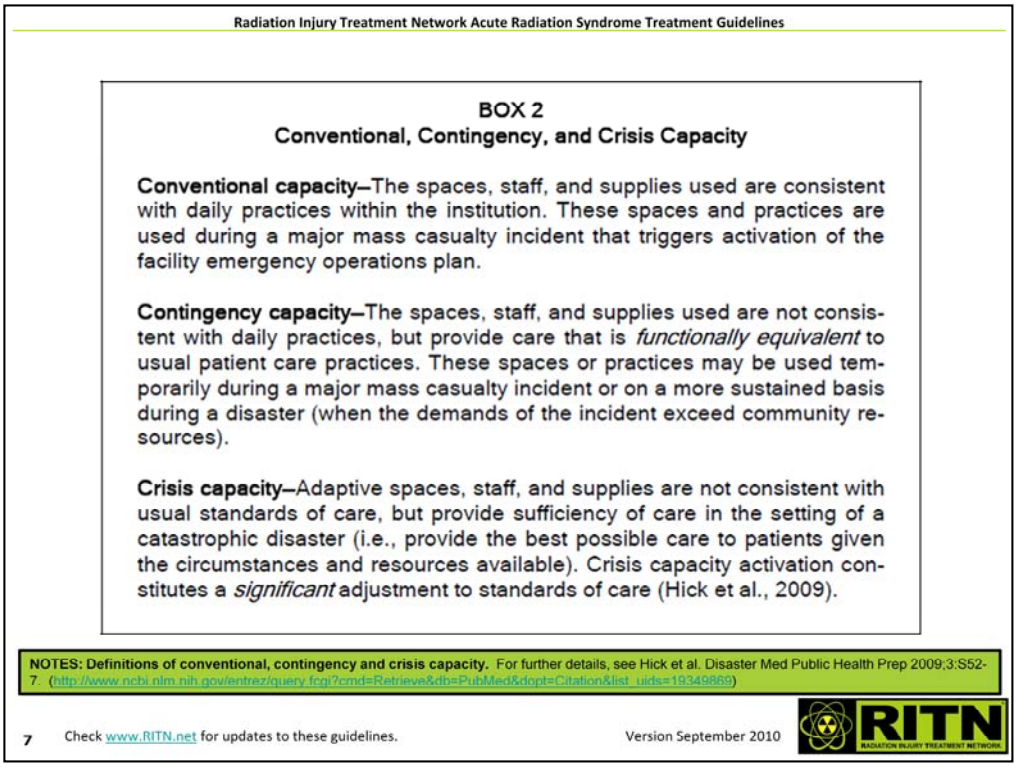



**Expected response to a nuclear detonation**. This stylized diagram illustrates the expected flow of victims from the effected area to specialty centers around the country, including RITN. The injury pattern and required resources will vary depending on the location relative to the blast. Victims are expected to undergo decontamination prior to triage for evacuation.

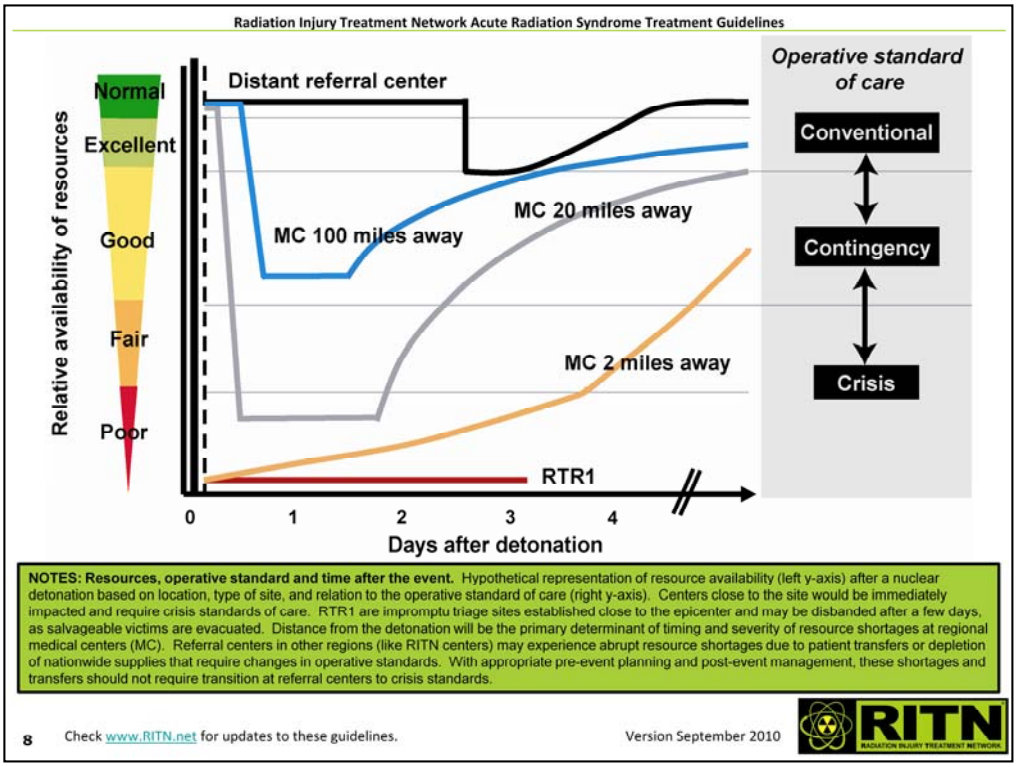
# Altered standards after a nuclear detonation




**Institute of Medicine Guidance for Establishing Crisis Standards of Care for Use in Disaster Situations** (http://www.iom.edu/Reports/2009/DisasterCareStandards.aspx). The table describes the transition across different Standards of Care at individual medical venues, based on the discrepancy between available resources and need. Transition from conventional (normal operations) to contingency indicates a functional equivalent of routine care through alterations in approach (*e.g.* repurposing units, extending staff, substituting supplies). In contrast, transition to crisis standards occurs when a functionally equivalent of normal care cannot be maintained (*e.g.* severely injured victims must be triaged to expectant care) because of inadequate resources. See next slide for further details.

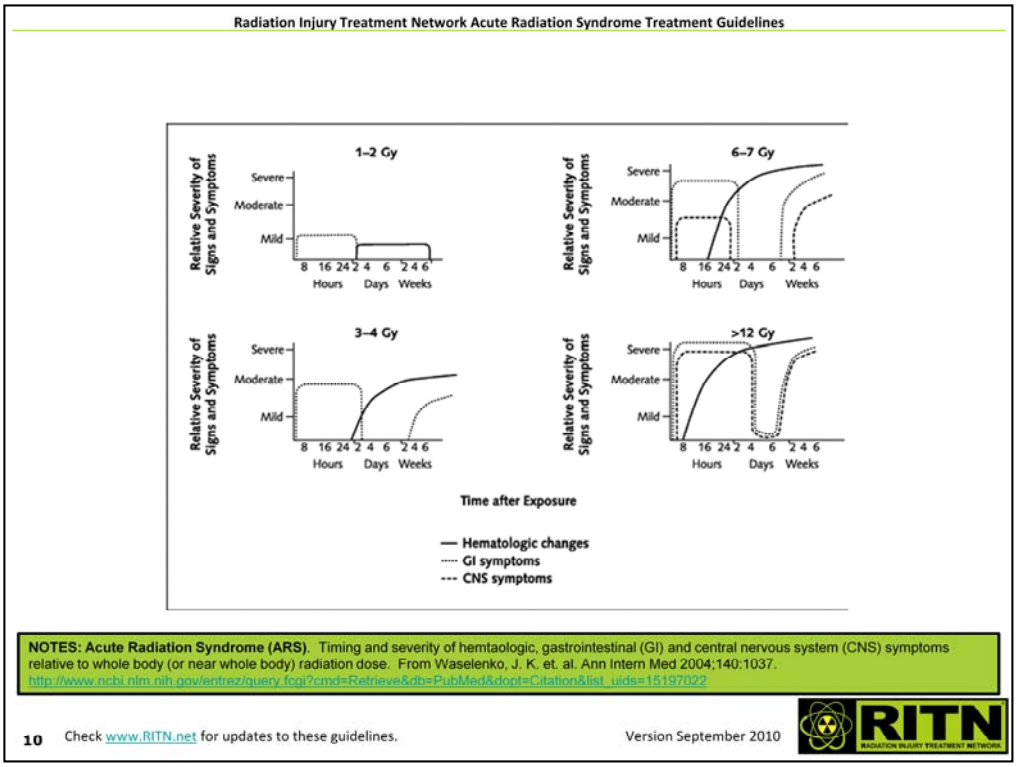



**Definitions of conventional, contingency and crisis capacity.** For further details, see Hick et al. Disaster Med Public Health Prep 2009;3:S52-7. (http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19349869)

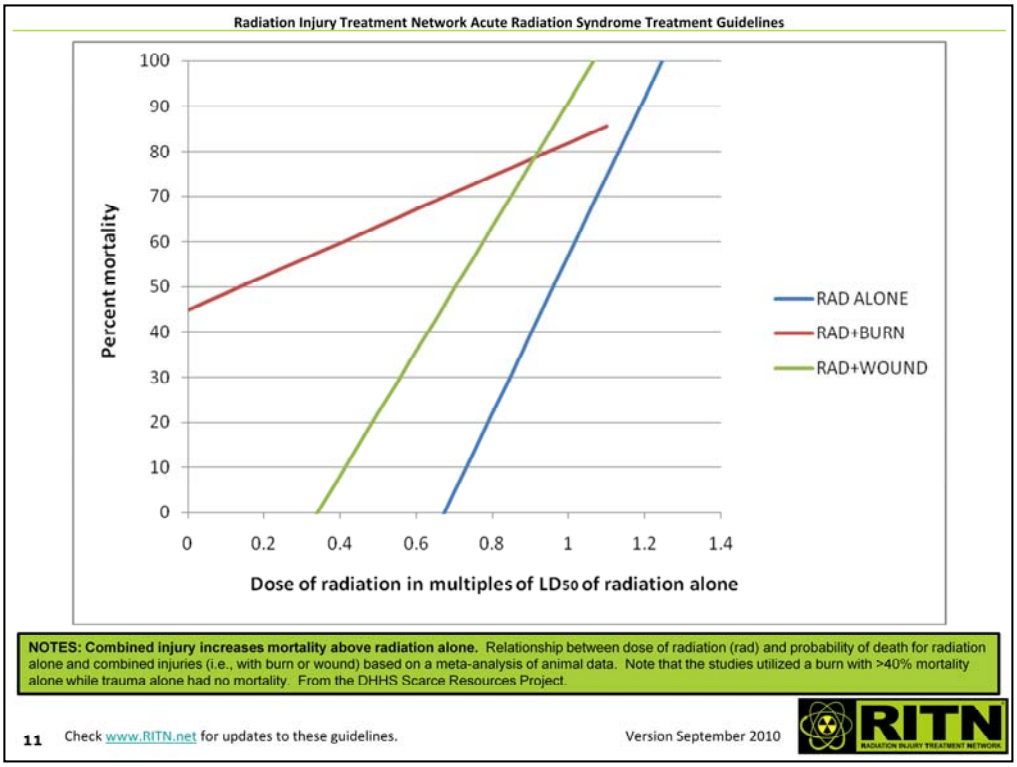



**Resources, operative standard and time after the event.** Hypothetical representation of resource availability (left y-axis) after a nuclear detonation based on location, type of site, and relation to the operative standard of care (right y-axis). Centers close to the site would be immediately impacted and require crisis standards of care. RTR1 are impromptu triage sites established close to the epicenter and may be disbanded after a few days, as salvageable victims are evacuated. Distance from the detonation will be the primary determinant of timing and severity of resource shortages at regional medical centers (MC). Referral centers in other regions (like RITN centers) may experience abrupt resource shortages due to patient transfers or depletion of nationwide supplies that require changes in operative standards. With appropriate pre-event planning and post-event management, these shortages and transfers should not require transition at referral centers to crisis standards.

# Acute Radiation Syndrome

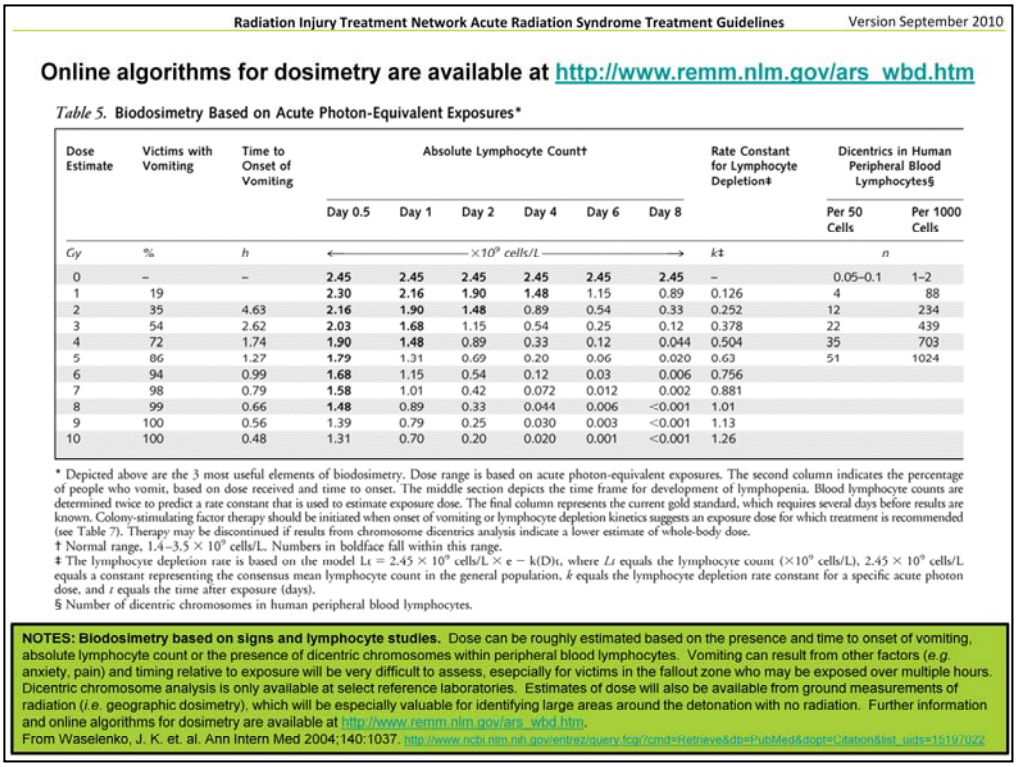



**Acute Radiation Syndrome (ARS)**. Timing and severity of hemtaologic, gastrointestinal (GI) and central nervous system (CNS) symptoms relative to whole body (or near whole body) radiation dose. From Waselenko, J. K. et. al. Ann Intern Med 2004;140:1037.
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15197022




**Combined injury increases mortality above radiation alone.** Relationship between dose of radiation (rad) and probability of death for radiation alone and combined injuries (i.e., with burn or wound) based on a meta-analysis of animal data. Note that the studies utilized a burn with >40% mortality alone while trauma alone had no mortality. From the DHHS Scarce Resources Project.

# Victim triage after a nuclear detonation



Radiation Injury Treatment Network Acute Radiation Syndrome Treatment Guidelines Version September 2010

**Online algorithms for dosimetry are available at http://www.remm.nlm.gov/ars_wbd.htm**

*Table 5.* Biodosimetry Based on Acute Photon-Equivalent Exposures*

| Dose Estimate | Victims with Vomiting | Time to Onset of Vomiting | Absolute Lymphocyte Count† | | | | | | Rate Constant for Lymphocyte Depletion‡ | Dicentrics in Human Peripheral Blood Lymphocytes§ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Day 0.5 | Day 1 | Day 2 | Day 4 | Day 6 | Day 8 | | Per 50 Cells | Per 1000 Cells |
| *Gy* | % | *h* | ← | | | $\times 10^9$ cells/L | | → | *k*‡ | *n* | |
| 0 | – | – | **2.45** | **2.45** | **2.45** | **2.45** | **2.45** | **2.45** | – | 0.05–0.1 | 1–2 |
| 1 | 19 | | **2.30** | **2.16** | **1.90** | **1.48** | 1.15 | 0.89 | 0.126 | 4 | 88 |
| 2 | 35 | 4.63 | **2.16** | **1.90** | **1.48** | 0.89 | 0.54 | 0.33 | 0.252 | 12 | 234 |
| 3 | 54 | 2.62 | **2.03** | **1.68** | 1.15 | 0.54 | 0.25 | 0.12 | 0.378 | 22 | 439 |
| 4 | 72 | 1.74 | **1.90** | **1.48** | 0.89 | 0.33 | 0.12 | 0.044 | 0.504 | 35 | 703 |
| 5 | 86 | 1.27 | **1.79** | 1.31 | 0.69 | 0.20 | 0.06 | 0.020 | 0.63 | 51 | 1024 |
| 6 | 94 | 0.99 | **1.68** | 1.15 | 0.54 | 0.12 | 0.03 | 0.006 | 0.756 | | |
| 7 | 98 | 0.79 | **1.58** | 1.01 | 0.42 | 0.072 | 0.012 | 0.002 | 0.881 | | |
| 8 | 99 | 0.66 | **1.48** | 0.89 | 0.33 | 0.044 | 0.006 | <0.001 | 1.01 | | |
| 9 | 100 | 0.56 | 1.39 | 0.79 | 0.25 | 0.030 | 0.003 | <0.001 | 1.13 | | |
| 10 | 100 | 0.48 | 1.31 | 0.70 | 0.20 | 0.020 | 0.001 | <0.001 | 1.26 | | |

* Depicted above are the 3 most useful elements of biodosimetry. Dose range is based on acute photon-equivalent exposures. The second column indicates the percentage of people who vomit, based on dose received and time to onset. The middle section depicts the time frame for development of lymphopenia. Blood lymphocyte counts are determined twice to predict a rate constant that is used to estimate exposure dose. The final column represents the current gold standard, which requires several days before results are known. Colony-stimulating factor therapy should be initiated when onset of vomiting or lymphocyte depletion kinetics suggests an exposure dose for which treatment is recommended (see Table 7). Therapy may be discontinued if results from chromosome dicentrics analysis indicate a lower estimate of whole-body dose.

† Normal range, 1.4–3.5 $\times 10^9$ cells/L. Numbers in boldface fall within this range.

‡ The lymphocyte depletion rate is based on the model $Lt = 2.45 \times 10^9$ cells/L $\times e - k(D)t$, where $Lt$ equals the lymphocyte count ($\times 10^9$ cells/L), $2.45 \times 10^9$ cells/L equals a constant representing the consensus mean lymphocyte count in the general population, $k$ equals the lymphocyte depletion rate constant for a specific acute photon dose, and $t$ equals the time after exposure (days).

§ Number of dicentric chromosomes in human peripheral blood lymphocytes.

**NOTES: Biodosimetry based on signs and lymphocyte studies.** Dose can be roughly estimated based on the presence and time to onset of vomiting, absolute lymphocyte count or the presence of dicentric chromosomes within peripheral blood lymphocytes. Vomiting can result from other factors (*e.g.* anxiety, pain) and timing relative to exposure will be very difficult to assess, esepcially for victims in the fallout zone who may be exposed over multiple hours. Dicentric chromosome analysis is only available at select reference laboratories. Estimates of dose will also be available from ground measurements of radiation (*i.e.* geographic dosimetry), which will be especially valuable for identifying large areas around the detonation with no radiation. Further information and online algorithms for dosimetry are available at http://www.remm.nlm.gov/ars_wbd.htm.
From Waselenko, J. K. et. al. Ann Intern Med 2004;140:1037. http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15197022

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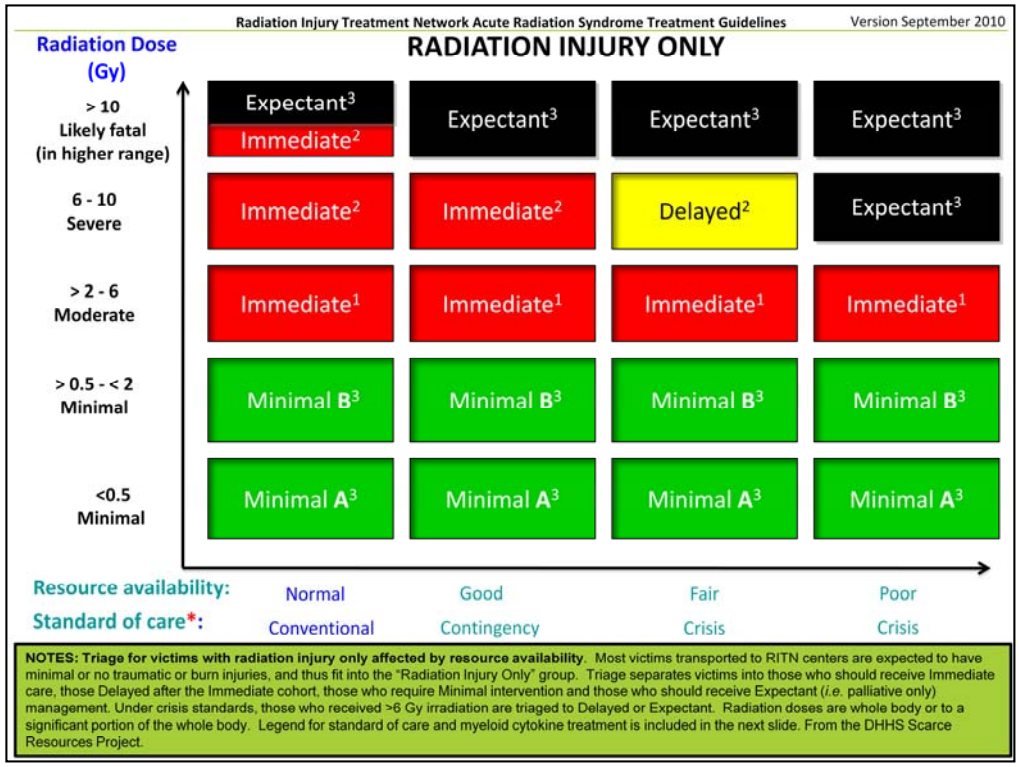
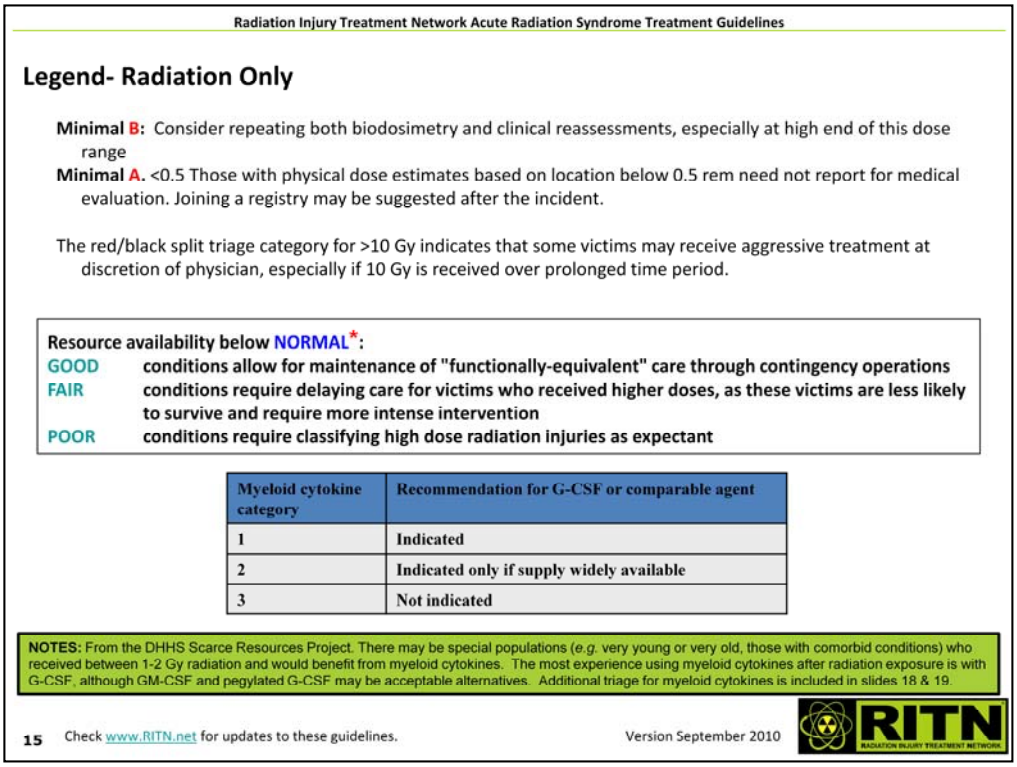



**Triage for victims with radiation injury only affected by resource availability**. Most victims transported to RITN centers are expected to have minimal or no traumatic or burn injuries, and thus fit into the "Radiation Injury Only" group. Triage separates victims into those who should receive Immediate care, those Delayed after the Immediate cohort, those who require Minimal intervention and those who should receive Expectant (*i.e.* palliative only) management. Under crisis standards, those who received >6 Gy irradiation are triaged to Delayed or Expectant. Radiation doses are whole body or to a significant portion of the whole body. Legend for standard of care and myeloid cytokine treatment is included in the next slide. From the DHHS Scarce Resources Project.





## Legend- Radiation Only

**Minimal B:** Consider repeating both biodosimetry and clinical reassessments, especially at high end of this dose range

**Minimal A.** <0.5 Those with physical dose estimates based on location below 0.5 rem need not report for medical evaluation. Joining a registry may be suggested after the incident.

The red/black split triage category for >10 Gy indicates that some victims may receive aggressive treatment at discretion of physician, especially if 10 Gy is received over prolonged time period.

**Resource availability below NORMAL*:**

**GOOD** conditions allow for maintenance of "functionally-equivalent" care through contingency operations

**FAIR** conditions require delaying care for victims who received higher doses, as these victims are less likely to survive and require more intense intervention

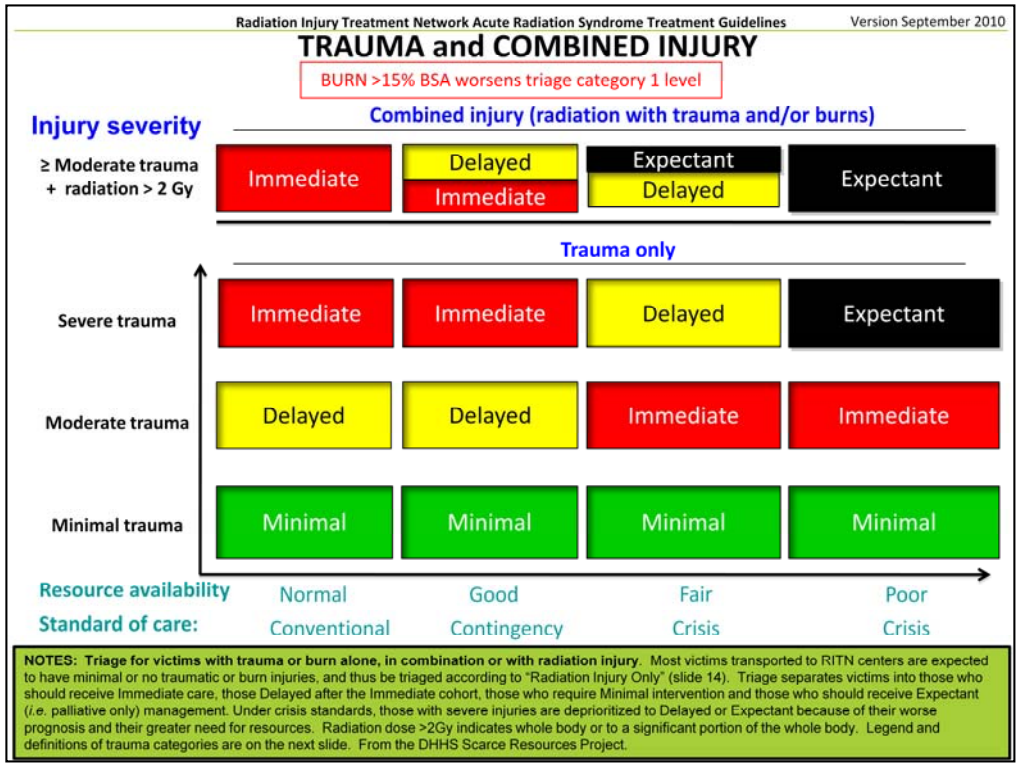
**POOR** conditions require classifying high dose radiation injuries as expectant

| Myeloid cytokine category | Recommendation for G-CSF or comparable agent |
|---|---|
| 1 | Indicated |
| 2 | Indicated only if supply widely available |
| 3 | Not indicated |

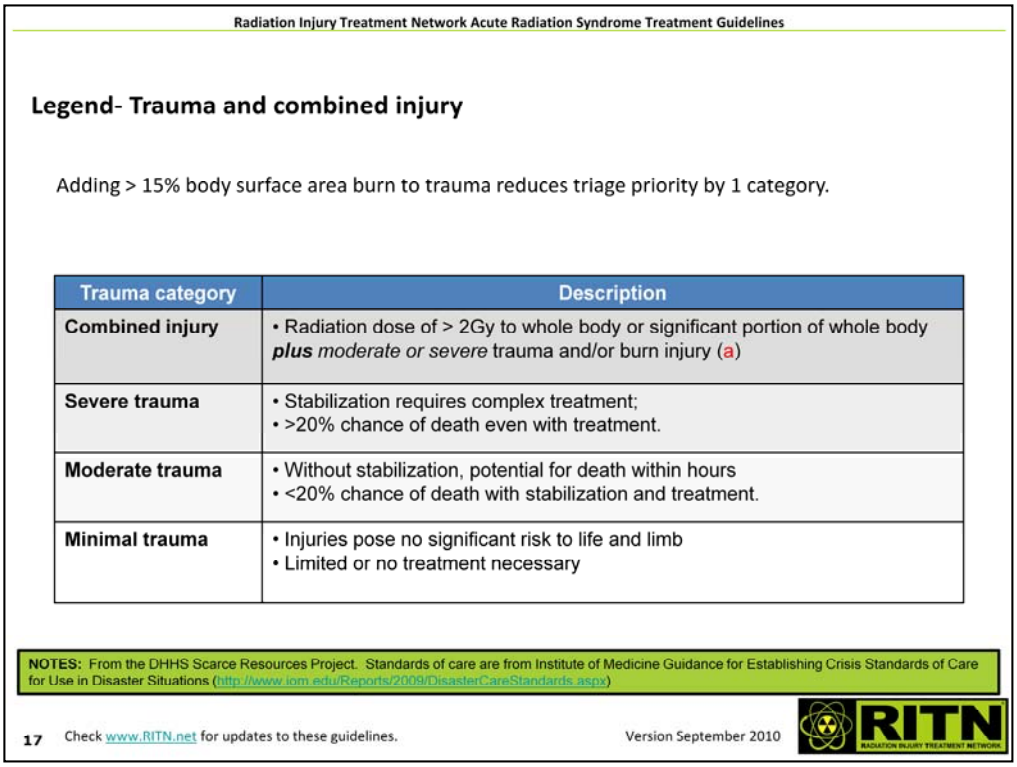
**NOTES:** From the DHHS Scarce Resources Project. There may be special populations (*e.g.* very young or very old, those with comorbid conditions) who received between 1-2 Gy radiation and would benefit from myeloid cytokines. The most experience using myeloid cytokines after radiation exposure is with G-CSF, although GM-CSF and pegylated G-CSF may be acceptable alternatives. Additional triage for myeloid cytokines is included in slides 18 & 19.



From the DHHS Scarce Resources Project. There may be special populations (*e.g.* very young or very old, those with comorbid conditions) who received between 1-2 Gy radiation and would benefit from myeloid cytokines. The most experience using myeloid cytokines after radiation exposure is with G-CSF, although GM-CSF and pegylated G-CSF may be acceptable alternatives. Additional triage for myeloid cytokines is included in slides 18 & 19.




**Triage for victims with trauma or burn alone, in combination or with radiation injury**. Most victims transported to RITN centers are expected to have minimal or no traumatic or burn injuries, and thus be triaged according to "Radiation Injury Only" (slide 14). Triage separates victims into those who should receive Immediate care, those Delayed after the Immediate cohort, those who require Minimal intervention and those who should receive Expectant (*i.e.* palliative only) management. Under crisis standards, those with severe injuries are deprioritized to Delayed or Expectant because of their worse prognosis and their greater need for resources. Radiation dose >2Gy indicates whole body or to a significant portion of the whole body. Legend and definitions of trauma categories are on the next slide. From the DHHS Scarce Resources Project.





## Legend- Trauma and combined injury

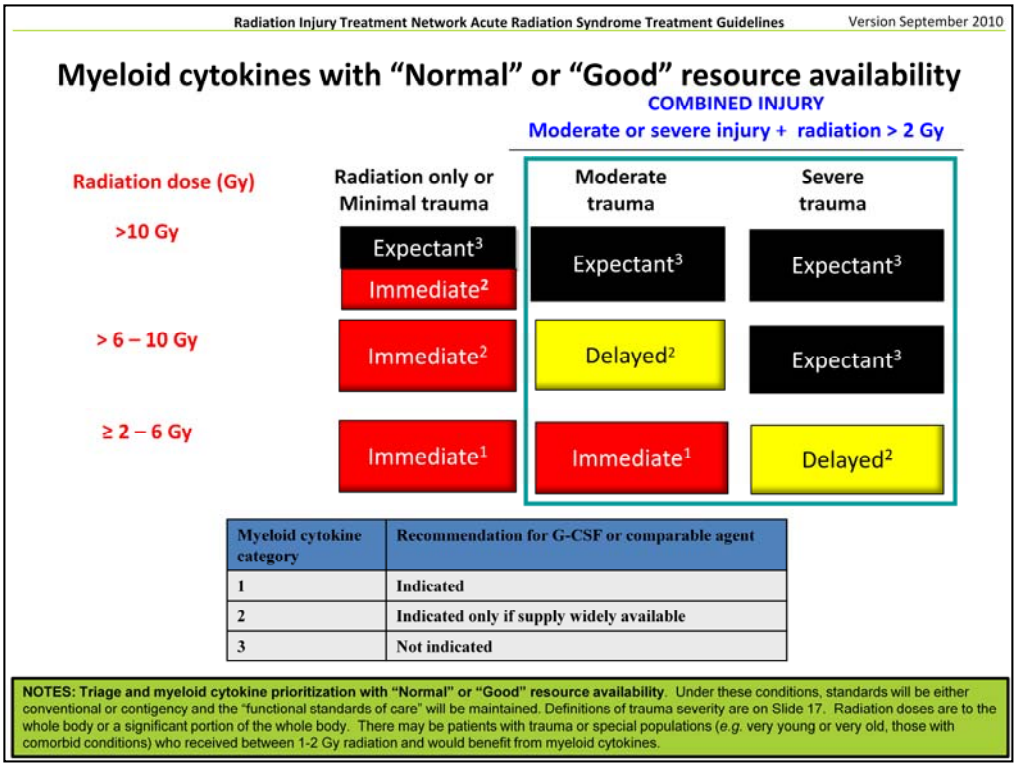
Adding > 15% body surface area burn to trauma reduces triage priority by 1 category.

| Trauma category | Description |
|---|---|
| **Combined injury** | • Radiation dose of > 2Gy to whole body or significant portion of whole body ***plus*** *moderate or severe* trauma and/or burn injury (a) |
| **Severe trauma** | • Stabilization requires complex treatment;<br>• >20% chance of death even with treatment. |
| **Moderate trauma** | • Without stabilization, potential for death within hours<br>• <20% chance of death with stabilization and treatment. |
| **Minimal trauma** | • Injuries pose no significant risk to life and limb<br>• Limited or no treatment necessary |

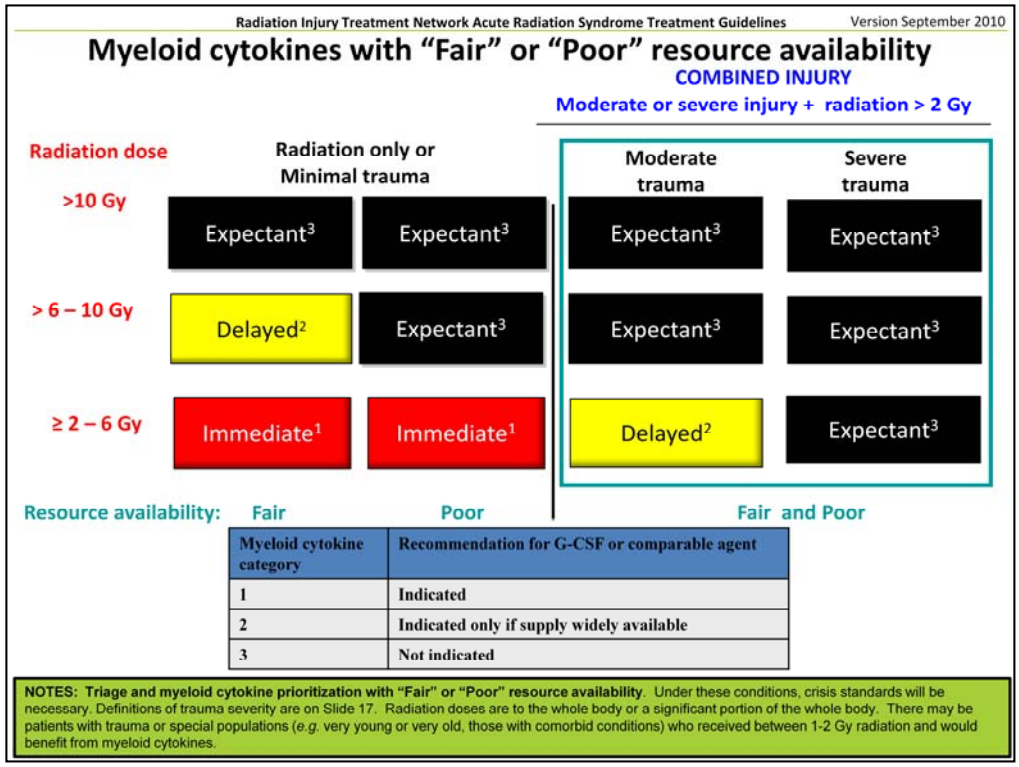
**NOTES:** From the DHHS Scarce Resources Project. Standards of care are from Institute of Medicine Guidance for Establishing Crisis Standards of Care for Use in Disaster Situations (http://www.iom.edu/Reports/2009/DisasterCareStandards.aspx)



From the DHHS Scarce Resources Project. Standards of care are from Institute of Medicine Guidance for Establishing Crisis Standards of Care for Use in Disaster Situations (http://www.iom.edu/Reports/2009/DisasterCareStandards.aspx)




**Triage and myeloid cytokine prioritization with "Normal" or "Good" resource availability**. Under these conditions, standards will be either conventional or contigency and the "functional standards of care" will be maintained. Definitions of trauma severity are on Slide 17. Radiation doses are to the whole body or a significant portion of the whole body. There may be patients with trauma or special populations (*e.g.* very young or very old, those with comorbid conditions) who received between 1-2 Gy radiation and would benefit from myeloid cytokines.




**Triage and myeloid cytokine prioritization with "Fair" or "Poor" resource availability**. Under these conditions, crisis standards will be necessary. Definitions of trauma severity are on Slide 17. Radiation doses are to the whole body or a significant portion of the whole body. There may be patients with trauma or special populations (*e.g.* very young or very old, those with comorbid conditions) who received between 1-2 Gy radiation and would benefit from myeloid cytokines.

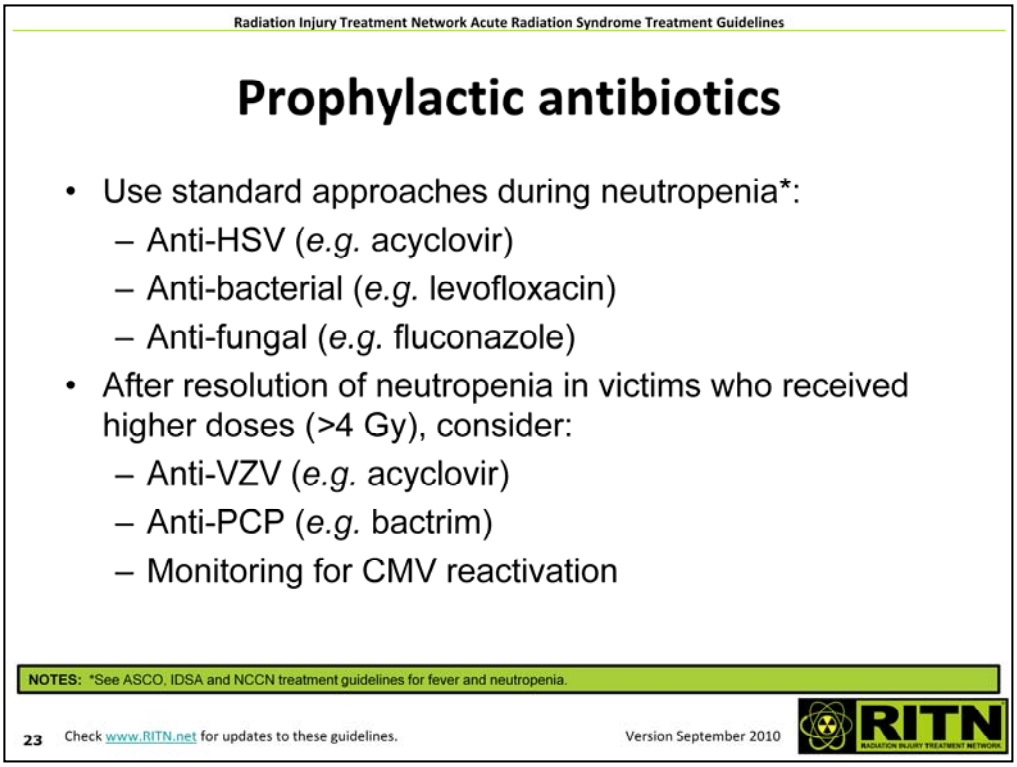
# ARS management

# Myeloid cytokines

- In animal studies, overall survival is improved if G-CSF is initiated within 24 hours after radiation exposure and continued until resolution of neutropenia
- Transfer to RITN centers is not expected for multiple days-weeks after exposure and many victims will have received no or inconsistent cytokines prior to transfer
- At RITN centers, use of myeloid cytokines should follow standard approaches with the goal of shortening neutropenia and preventing neutropenia-associated complications

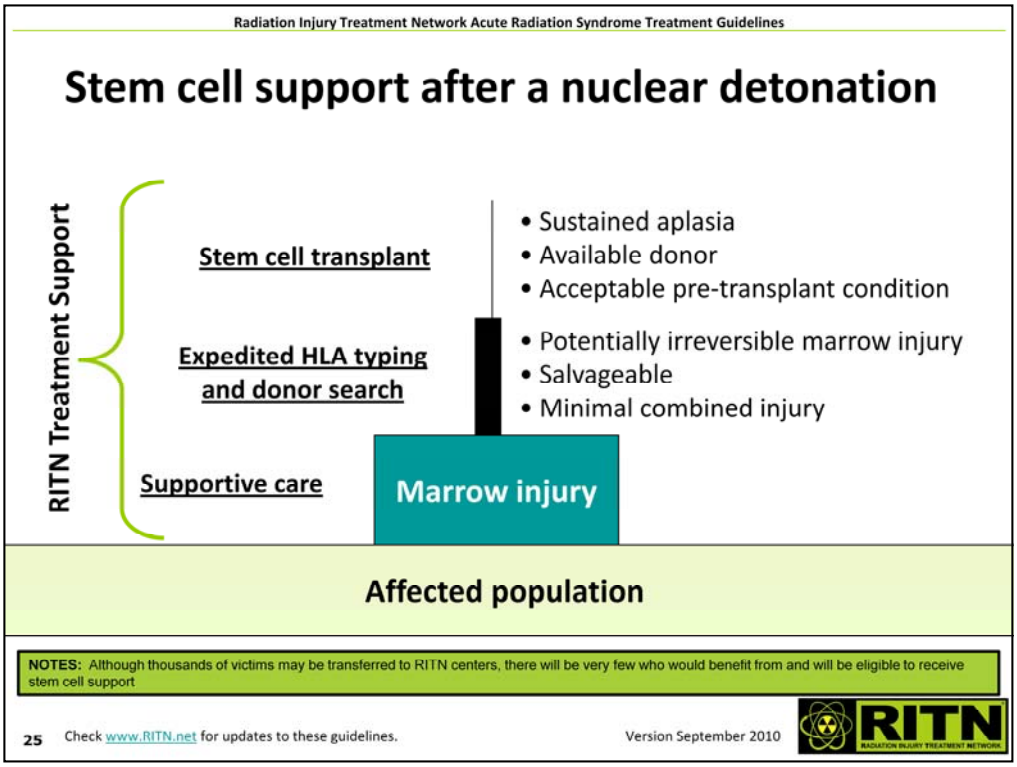
# Transfusions

- Unless the victim is known to have received < 1Gy irradiation, **all transfused blood products should be irradiated and leukoreduced**
- Assuming adequate resource availability, standard thresholds for transfusions should be utilized

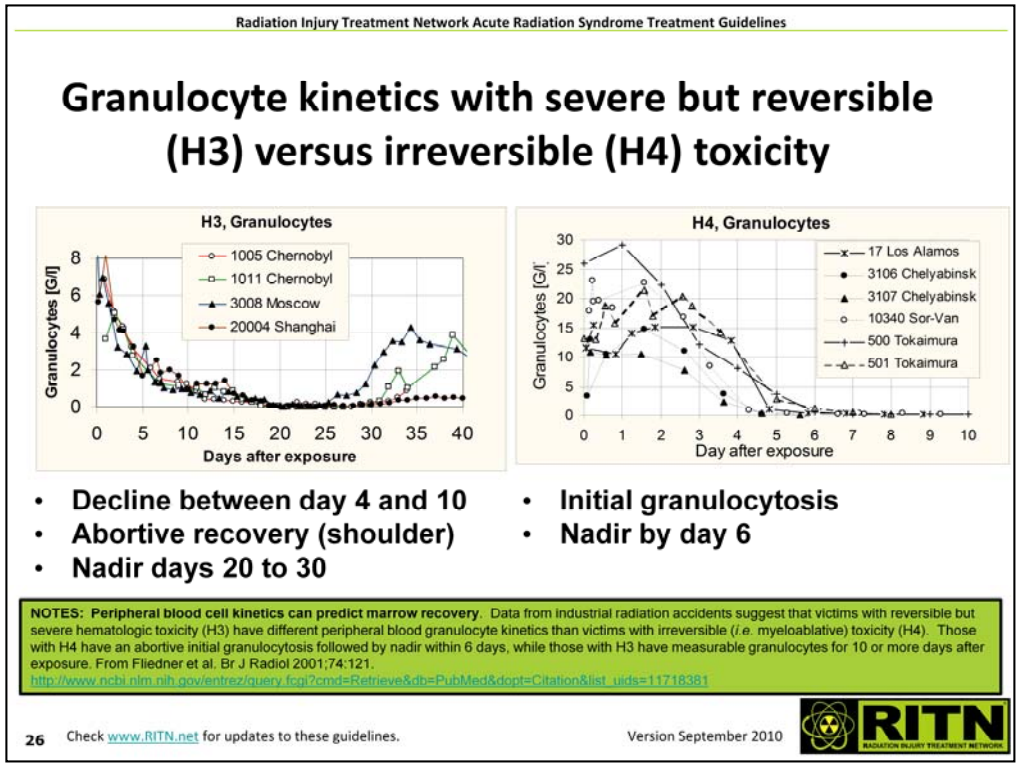



*See ASCO, IDSA and NCCN treatment guidelines for fever and neutropenia.

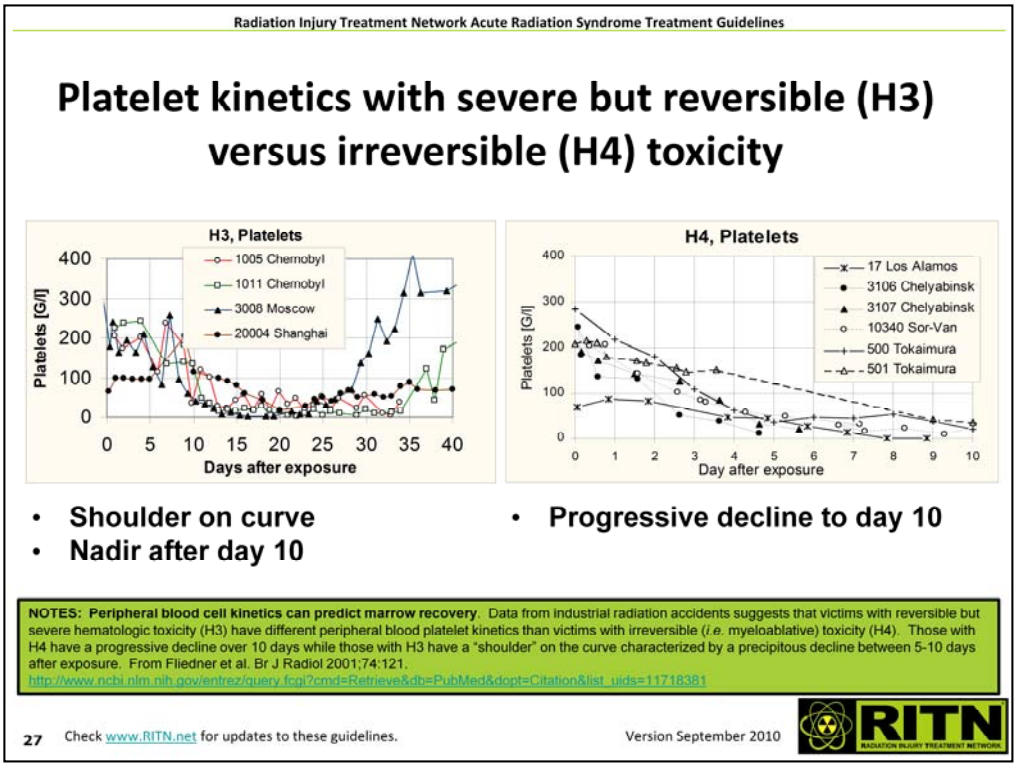
# Stem cell support




Although thousands of victims may be transferred to RITN centers, there will be very few who would benefit from and will be eligible to receive stem cell support




**Peripheral blood cell kinetics can predict marrow recovery**. Data from industrial radiation accidents suggest that victims with reversible but severe hematologic toxicity (H3) have different peripheral blood granulocyte kinetics than victims with irreversible (*i.e.* myeloablative) toxicity (H4). Those with H4 have an abortive initial granulocytosis followed by nadir within 6 days, while those with H3 have measurable granulocytes for 10 or more days after exposure. From Fliedner et al. Br J Radiol 2001;74:121. http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11718381




**Peripheral blood cell kinetics can predict marrow recovery**. Data from industrial radiation accidents suggests that victims with reversible but severe hematologic toxicity (H3) have different peripheral blood platelet kinetics than victims with irreversible (*i.e.* myeloablative) toxicity (H4). Those with H4 have a progressive decline over 10 days while those with H3 have a "shoulder" on the curve characterized by a precipitous decline between 5-10 days after exposure. From Fliedner et al. Br J Radiol 2001;74:121. http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11718381

# Decision to perform HLA typing

Factors favoring HLA typing

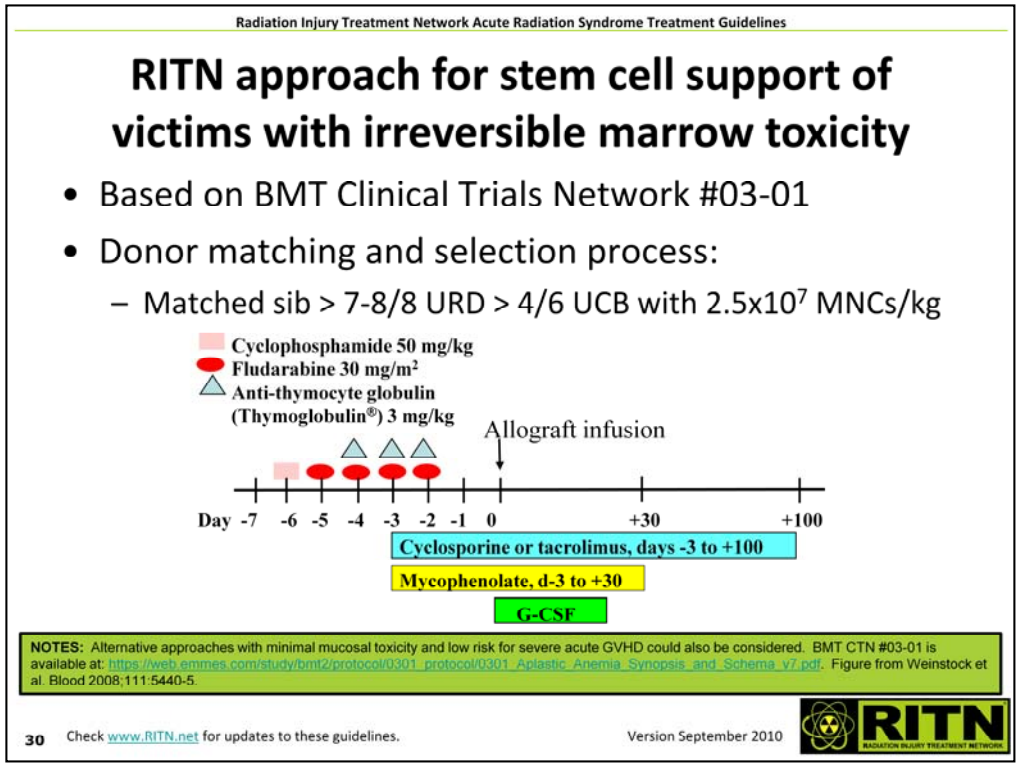
- Estimated whole body dose > 3 Gy
- Neutrophil count < 100/μl by day 6 (see slide 26)
- Rapid drop of platelets (see slide 27)
- Expected to survive other injuries

Expedited HLA typing will be available using buccal swab, with high resolution DNA typing of HLA-A, -B, -C, -DRB1, and -DQB1

# Decision to proceed with stem cell support

Factors favoring stem cell support

- Estimated whole body dose > 3Gy
- Neutrophil and platelet count kinetics consistent with irreversible (H4) toxicity (see slides 26 and 27)
- Peripheral blood neutrophil count < 100/uL extending beyond 14 despite >5 days of myeloid cytokines
- Expected to survive other injuries
- Aplastic marrow at 2 or more sites on day 14-21
- Suitable HLA compatible donor available




Alternative approaches with minimal mucosal toxicity and low risk for severe acute GVHD could also be considered. BMT CTN #03-01 is available at: https://web.emmes.com/study/bmt2/protocol/0301_protocol/0301_Aplastic_Anemia_Synopsis_and_Schema_v7.pdf. Figure from Weinstock et al. Blood 2008;111:5440-5.

# Additional resources

Radiation Injury Treatment Network (RITN): www.RITN.net

Radiation Emergency Medical Management (REMM): www.remm.nlm.gov

Radiation Emergency Assistance Center/Training Site (REAC/TS): www.orau.gov/reacts

Radiation Countermeasures Center of Research Excellence (RadCCORE): www.radccore.org

Armed Forces Radiobiology Research Institute (AFRRI): www.afrri.usuhs.mil

IAEA Library: http://www.iaea.org/DataCenter/Library/catresources.html

TMT Handbook:

http://www.nrpa.no/dav/de688664a2.pdf