In the triage module, I described how victims of a mass casualty radiological or nuclear incident may present to the hospital with combined injuries – that is, physical, thermal, and/or chemical trauma combined with an exposure to radiation at doses sufficient to threaten overall survival or recovery.

Treatment decisions for victims of radiation exposure may be based on the characteristic physical findings of the prodromal phase of Acute Radiation Syndrome – nausea and vomiting and fever – and also on complete blood count results.

I’m now going to continue the discussion of Combined Injury Management by emphasizing the importance of:

- conducting a complete trauma survey
- taking an appropriately directed history
- conducting a contamination assessment
- and, ordering some additional laboratory studies

Your ability to perform some – or all – of these activities may be limited by the numbers of victims and the depletion of available resources and health care infrastructure during a mass casualty event.

Despite the added burden of injury caused by radiation exposure, resuscitation and stabilization remain the primary objectives of patient management.

- Remember: contamination surveys and decontamination efforts should be secondary to patient stabilization
- Assessment and management of airway, breathing and circulation – the ABCs – as well as identifying and treating penetrating and blunt trauma, and blast effect injuries are of critical importance
- Whenever possible, clinicians should attempt to identify the cause for impaired central nervous system functioning – an altered mental status in the absence of traumatic head injury indicates a high dose of radiation exposure and poor prognosis
- Also as part of the trauma survey, thermal or chemical burns should be distinguished from Cutaneous Radiation Injury

Several factors distinguish thermal or chemical burns from cutaneous radiation injury or CRI.

- CRI is less likely to be seen in the immediate post-exposure time period
- Thermal burns are typically painful while irradiated tissue might be somewhat edematous and feel “stretched” or “itchy”
- Depending on the depth of the burn, thermal burns or chemical burns typically show loss of hair in the involved areas along with tissue loss
By contrast, the primary erythema caused by a cutaneous radiation injury is not accompanied by obvious loss of tissue and there is no hair loss.

More typically, hair loss as a result of CRI does not occur for 2 to 3 weeks after an exposure.

Unlike severe thermal or chemical burns, the initial skin damage caused by CRI may begin to show signs of healing after several weeks.

This may then be followed months later by ulceration.

Like severe thermal and chemical burns, CRI lesions can be debilitating and life threatening and medical follow-up is essential.

In addition, victims should be cautioned to avoid additional trauma to involved areas. The outcome of these injuries is dependent on the total dose of radiation received and the total body surface area irradiated.

Another key aspect to the management of a combined injury patient – as it is with nearly all patient evaluations – involves obtaining an exposure history.

If available, information about

- proximity to the radiation source
- time of initial exposure
- total duration of exposure
- and time to onset of vomiting – if not witnessed by the clinician – can provide clues as to the dose of exposure and the patient’s prognosis

This information can help to establish the likelihood of exposure, and the potential that internal and/or external contamination may have occurred.

A contamination assessment – where possible – can provide the clinician with additional important information about victims of radiation exposure. However, as I noted earlier, patient stabilization should not be delayed in favor of conducting contamination surveys and decontamination.

If readily available, screening for contamination should be completed as part of the survey of a patient presenting with combined injury.

In their absence, clinicians should assume that the victim of a combined injury is externally contaminated and provide initial decontamination through a careful removal of clothing.

Any further attempts at decontamination should be delayed until after the patient has been adequately stabilized and resuscitated as per Advanced Trauma Life Support protocols.

In my lecture dealing with victim triage, I discussed the importance of establishing a baseline lymphocyte count and tracking that count over time.

Doing so can provide an estimation of the dose of radiation absorbed by a patient and this will allow clinicians to better predict outcome and allocate resources.

In a mass casualty situation involving hundreds or even thousands of victims, tracking lymphocyte counts may be the best – and most readily available – means for assessing the dose of radiation to which individuals have been exposed.
In the face of such an event, however, the availability of laboratory staff and resources may be significantly compromised.

The sheer volume of specimens generated following such an event is likely to tax hospital laboratory capabilities even if infrastructure and staffing remain fully in place.

Planning for a radiation or nuclear mass casualty event therefore must include discussions about how to appropriately collect and label numerous specimens to facilitate their timely and correct analysis.

Other tests that clinicians may consider obtaining include:

- Serum amylase: a rise in serum amylase levels is a sensitive, but non-specific marker of radiation injury to the salivary glands
- Type and cross match: for patients requiring surgery, blood products should be prepared in advance and the use of irradiated blood products is recommended to prevent transfusion of live white blood cells and to reduce the chance of subsequent graft vs. host disease.
- Where possible, additional blood samples should be drawn into heparinized tubes and refrigerated.
  - These samples may then be sent to a specialized laboratory for analysis by advanced techniques known as cytogenetic dosimetry
  - Cytogenetic dosimetry is considered the “gold standard” for retrospectively determining the dose of radiation absorbed by an individual
  - Although this test can provide clinicians with highly accurate estimates of the radiation dose absorbed by a patient, it is unlikely that results from these tests would be available to emergency clinicians or clinicians managing victims within the first 24–48 hours post-exposure. These results can, however, help guide management decisions for clinicians involved in the longer-term care of these patients.

Another laboratory study that can aid in proper patient management is the analysis of urine for radioactivity.

A 24-hour collection of urine should be initiated in the emergency department – the presence of radioactivity in the urine is highly suggestive of internal contamination and can indicate an urgent need for decontamination.

In terms of treatment priorities in a combined injury patient, traumatic injuries must be assessed and managed first.

In the first part of this lecture, I emphasized the importance of assessing and managing the ABCs and conducting a complete and thorough trauma survey — proper early trauma management can help ensure the long-term survival of a victim, early decontamination cannot.

That having been said, all open wounds identified during a trauma survey should be considered contaminated with radioactivity — timely decontamination of open wounds is a necessary part of the management of these patients.

In addition — in order to protect the hospital staff — all visible pieces of shrapnel should be assumed to be radioactive and removed and stored in shielded containers.
Current guidelines call for early surgery – within the first 36–48 hours in patients with combined injury – before the effects of bone marrow injury occur and platelet and white cell counts begin to fall.

Even when indicated surgery is completed within the recommended time frame, patients with combined injuries are at risk for:

- Post-operative bleeding
- Prolonged and impaired tissue healing
- Delayed callous formation in fractured bones
- Other post operative complications aggravated by ARS.

Having spent the last little while talking about the emergency management of combined injuries, I would now like to briefly discuss the early management of victims of atraumatic irradiation injury.

The absence of trauma makes the management of victims of atraumatic irradiation somewhat less complicated than that of combined injury patients.

The key concepts in taking care of a patient with atraumatic irradiation are essentially the same as those for a combined injury patient:

1: Obtain a focused history
2: Assess for the presence of Adverse Health Effects
3: Where possible, complete a contamination assessment
And 4: Use the laboratory to help make the diagnosis.

First, obtain a focused history – including a medical history – and details about the individual’s exposure to the radiation:

- Where was the victim relative to the radiation source?
- For how long was the victim exposed?
- Has the victim vomited and if so, when?
- Did the victim lose consciousness?
- Has the victim been decontaminated prior to their arrival to the emergency department?

Next, use physical examination findings just as you would for assessing an individual with combined injury.

- A rise in core body temperature and witnessed vomiting provide clues as to the likelihood of an individual having ARS and the severity of their illness.
- Additional clues on physical examination can be indicators of acute radiation exposure – these include skin erythema, nausea, salivary gland inflammation, headache, fatigue, and otherwise unexplained mental status changes.

After completing a history and physical examination – if personnel and equipment are available – emergency staff should conduct a contamination assessment to identify contamination.

- As an alternative, portal monitors provide rapid screening of victims in a mass casualty situation.
- Uninjured victims of atraumatic irradiation who have been identified as also having external contamination may be able to assist in their own decontamination.

Finally, just as with victims of combined injury, obtaining a CBC with differential at baseline is key.
- This should be repeated at 4–6 hours and then every 6–8 hours thereafter to determine whether the absolute lymphocyte count is falling.
- A plot of the rate of decline provides the earliest laboratory indication of the dose of radiation to which a person was exposed, the severity of ARS, and the likelihood for recovery.
- Blood should also be collected and sent for cytogenetic dosimetry analysis
- And last, a 24-hour urine sample should be collected and analyzed for the presence of radioactivity which can serve as an indication of internal contamination.

In summary, then, victims of acute radiation exposure may – or may not – have additional traumatic injury.

Those persons having penetrating and/or blunt trauma and/or burns – in addition to acute radiation exposure – are said to have combined injury.

For these patients, management of traumatic injury takes precedence over radiological decontamination.

In patients with thermal or chemical burns, these should be distinguished from cutaneous radiation injury – the appropriate treatment differs for each.

Whether dealing with a victim of combined injury or a victim of atraumatic irradiation, obtaining an exposure history, identifying the time to onset of specific adverse health effects, conducting a contamination survey, and appropriate use of laboratory resources are the keys to proper triage, diagnosis, and management.
Treatment

1. Treatment Priorities
   a. Contamination surveys and decon efforts should be secondary to patient stabilization
   b. Airway, breathing, circulation

   Resuscitation and Stabilization
   Top Priority!

2. Triage Decisions
   a. Treatment decisions based on prodromal phase of ARS:
      • Nausea, vomiting, fever (onset, severity)
      • Absolute lymphocyte counts

3. Combined Injury Management
   a. Conducting a complete trauma survey
   b. Taking an appropriately directed history
   c. Conducting a contamination assessment
   d. Ordering additional laboratory studies

4. Trauma Survey
   a. Airway, breathing, circulation (ABC’s)
   b. Penetrating injuries
   c. Blunt trauma and blast effect
   d. Cause for impaired CNS functioning?
      • An altered mental status in the absence of traumatic head injury indicates a high dose of radiation exposure and poor prognosis.
5. Cutaneous Radiation Injury (CRI)

   a. Less likely to be seen immediately
   b. Immediate pain is rare finding
   c. Itching, tingling, erythema, edema more common
   d. Loss of hair occurs 2–3 weeks later
   e. Ulcerations can appear months later
   f. Initial skin damage may heal

   g. Avoid additional trauma
   h. Outcome depends on total dose received and size of irradiated area

(See also: "Cutaneous Radiation Injury: Fact Sheet for Physicians", http://www.bt.cdc.gov/radiation/criphysicianfactsheet.asp)

6. Exposure History

   a. Abbreviated medical history
   b. Proximity to radiation source
   c. Time initial exposure occurred
   d. Duration of exposure
   e. Time of onset of adverse health effects (vomiting)

7. Contamination Assessment

   a. Patient stabilization first priority
   b. Screen for contamination as part of survey
Treatment

8. Unable to Determine Contamination
   a. If personnel and survey instruments not available, assume victim is contaminated
   b. Decontaminate by removing clothing
   c. Delay further decontamination until patient stabilized per advanced trauma life support protocols

9. Laboratory Testing
   a. Baseline CBC with differential
   b. Track absolute lymphocyte count

   How will you collect and label numerous specimens in a mass casualty event?

   c. Serum amylase q24 hours
   d. Type and cross match
      • If transfusions needed, use irradiated blood products
   e. Collect and save additional blood samples in heparinized tubes for later analysis (Cytogenetic Dosimetry)
   f. Urine analysis
      • 24-hour urine sample collection
      • Monitor excretion of radioactivity
10. Treatment Priorities

a. Treat serious injuries
b. Consider all open wounds as contaminated
c. During initial trauma survey and external decontamination, assume visible metal pieces to be radioactive: remove and store in shielded containers
d. Is surgery indicated?
   • Complete within 36-48 hours; prior to onset of thrombocytopenia, leukopenia and immunosuppression, anemia
   • Patients at risk for prolonged and impaired tissue healing, delayed callous formation in fractures, and other post-operative complications
### Atraumatic Irradiation Management

11. **Atraumatic Irradiation Management**  
   Treatment decisions based on  
   a. Focused history (medical and exposure)  
   b. Adverse health effects (24–48 hours) and findings on physical examination  
   c. Contamination assessment  
   d. Laboratory test results

12. **Focused History**  
   a. Location? (inside or outside)  
   b. Vomiting/diarrhea? (onset; frequency of)  
   c. Loss of consciousness?  
   d. Decontamination?

13. **Physical Findings**  
   a. Rise in core body temp  
   b. Witnessed vomiting  
   c. Additional cues:  
      - erythema of skin, mucosa  
      - nausea / diarrhea  
      - salivary gland inflammation  
      - headache, fatigue,  
      - altered sensorium

14. **Contamination Assessment**  
   a. Trained personnel conduct contamination assessment or use portal monitors  
   b. Victims identified with external contamination may be able to self-decontaminate

15. **Laboratory Testing**  
   a. Baseline CBC with differential  
      - Absolute lymphocyte count  
   b. Serum amylase q24 hours  
      - Sensitive but not specific  
   c. Collect and save additional blood in heparinized tubes  
   d. 24-hour urine sample for cases of internal contamination
16. SUMMARY

a. Combined injury vs. atraumatic irradiation
b. Traumatic injury management takes precedence over radiological decontamination
c. Distinguish between thermal/chemical burns and radiation injury
d. Exposure history
e. Physical findings – prodrome onset
f. Contamination survey
g. Laboratory findings

Source: “Radiological and Nuclear Terrorism: Medical Response to Mass Casualties”, a self-study training program for clinicians, developed by the Centers for Disease Control and Prevention, 2006.

For copies of this product, email cdcinfo@cdc.gov.
To learn more about responding to a radiological incident, visit http://www.bt.cdc.gov/radiation