



The Role of Healthcare Providers in
Radiation Emergencies


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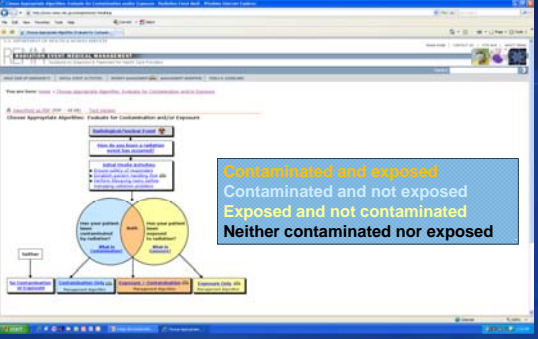


- This presentation includes a discussion of Neupogen® and its use in the treatment of patients diagnosed with Acute Radiation Syndrome (ARS).
- The use of this drug for the treatment of ARS has not been approved by the US Food and Drug Administration (FDA).
- However, in the event of a nuclear/radiological emergency, the Centers for Disease Control and Prevention can distribute Neupogen® from the Strategic National Stockpile under an Emergency Use Authorization approved by the FDA.




I have no relevant financial relationships that would bias this continuing education activity.






<http://remm.nlm.gov>



Approach to Victim Management

	Contamination	
Exposure	+/+	+/-
	-/+	-/-

- Contaminated and exposed
- Contaminated and not exposed
- Exposed and not contaminated
- Neither contaminated nor exposed



Contamination

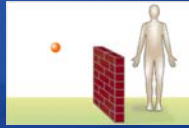
- Contamination

- External

- Radioactive material (liquid, solid, or gas) is deposited on skin, hair, eyes, clothing, etc.



- External contamination stops when material is removed by shedding contaminated clothing and/or other removal (e.g., washing)



Contamination

- Contamination

- Internal

- Radioactive material is inhaled, ingested, or enters body through open wounds



- Internal contamination stops when material decays, passes from the body on its own, or is removed by medical means



Victim Management: Contamination

- Handle threats to life and limb first
 - Rescue, transport, and deliver definitive care to acutely ill and injured before managing radiation contamination
- Minimally contaminated victims do not pose health risk to rescuers or healthcare providers
- Removing clothing can reduce contamination up to 90%



Victim Management: Contamination

Assess location and levels of contamination

See: <http://www.bt.cdc.gov/radiation/screeningvideos/>

- External Contamination
 - Scan with appropriate radiation survey meter and probes (α vs. β vs. γ)
- Internal Contamination
 - Radiation survey meter (γ , $\pm \beta$)
 - Modified nuclear medicine equipment (γ)
 - Swab orifices, obtain spot and/or 24 hour urine/stool sample (α)



Alpha probe

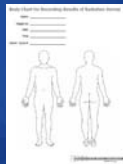


Beta/gamma probe



Victim Management: Contamination

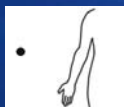
- Contamination survey
 - Recruit hospital staff with expertise in radiation detection
 - Survey patients
 - Hold probe ~1/2 inch from surface
 - Scan rate: 1 – 2 inches per second
 - Follow systematic pattern
 - Document readings in counts per minute on body chart
 - Compare radiation survey results before and after decontamination efforts



Victim Management: Contamination

Two key questions:

1. Is there evidence that victims of a rad/nuc emergency have become internally contaminated?
2. What radioisotopes were released?



Victim Management: Contamination

Key Question #1:

Is there evidence of internal contamination?



- Not simple to answer
- May require sophisticated testing
- Assume when *external* contamination has occurred, some subset may also be *internally* contaminated
- Requires collaboration with experts



Alexander Litvinenko

Millennium Hotel & Itsu Sushi Bar, London



- 1 Nov 2006: meets 2 Russians for tea at Millennium Hotel & later meets Italian security expert at Itsu sushi bar; that night falls ill
- 4 Nov: admitted to local hospital with abdominal pain
- 17 Nov: transferred to University College Hospital under armed guard



Alexander Litvinenko

Before and after Po-210

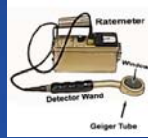


- 19 Nov: thallium poisoning suggested
- 20 Nov: moved to intensive care
- 22 Nov: now "critically ill," thallium ruled out as cause of sickness
- 23 Nov: Litvinenko dies
- 24 Nov: Health experts identify internal contamination with Po-210 as cause of ARS and death



Evidence of Internal Contamination

- Event history: Location, location, location...
 - Likelihood for inhalation or ingestion
- Physical exam: Open wounds containing shrapnel
- Bioassay
 - Blood
 - Urine
 - Stool



Evidence of Internal Contamination



- Nasal swabs*
 - Can help identify radioisotope
 - Radioactivity measured in nose is crude estimate of radioactivity inhaled into lung (under ideal conditions!)
 - Alpha-emitters will be masked by moisture on swab
 - ≥ 10 -fold discrepancy in radioactivity levels between left and right nostril suggests contamination by other means
 - Use of nasal swabs requires collaboration between health physics/radiation safety personnel and clinical subject matter experts

*In mass casualty events, collecting and analyzing nasal swabs may not be feasible due to numbers of patients, transportation issues, and limited laboratory capacity.



Victim Management: Contamination

Key Question #2:

What radioisotopes were released?



- Optimal treatment depends on radioisotope identification
- Need to *consider* possibility of multiple isotopes
- Incorporation (target organ binding) can occur rapidly
 - Time-dependent phenomenon
 - Related to physical properties of radioisotope



Victim Management: Contamination

- Each medical countermeasure interferes with the incorporation – or enhances the elimination – of *specific* radioisotopes
- Countermeasures become less effective over time



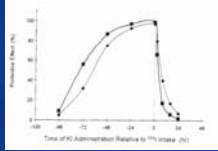


Radiation Medical Countermeasures Potassium iodide (KI)

- Blocking agent for radioiodine
- Comes in two FDA-approved oral formulations: tablets and liquid solution
- Tablets no longer stockpiled in SNS
- Taken orally once a day



Radiation Medical Countermeasures Potassium iodide (KI)



- KI ineffective if taken >4-6 hours after internal contamination has occurred
- Consider KI as a “supplementary public health measure”
- Primary prevention measures (e.g. shelter-in-place) to protect public from radioiodine release



	Predicted thyroid exposure (cGy)	KI dose (mg)	Number or fraction of 130 mg tablets	Number or fraction of 65 mg tablets	Milliliters (mL) of oral solution, 65 mg/mL
Adults over 40 years	≥ 500	130	1	2	2 mL
Adults over 18 through 40 years	≥ 10	130	1	2	2 mL
Pregnant or Lactating Women	≥ 5	130	1	2	2 mL
Adolescents, 12 through 18 years	≥ 5	65	1/2	1	1 mL
Children over 3 years through 12 years	≥ 5	65	1/2	1	1 mL
Children 1 month through 3 years	> 5	32	1/4	1/2	0.5 mL
Infants birth through 1 month	≥ 5	16		1/4	0.25 mL

<http://remm.nlm.gov/potassiumiodide.htm#dose>



Radiation Medical Countermeasures Calcium and Zinc DTPA

- FDA-approved chelating agent
- For treatment of internal contamination with plutonium, americium, and/or curium
- Stockpiled with SNS & also forward deployed / pre-positioned
- Given intravenously (IV) once a day
- Zinc DTPA for pregnant women and whenever multiple doses required



Radiation Medical Countermeasures Calcium and Zinc DTPA



- Works best if given shortly after internal contamination
 - After 24 hours, chelation becomes more difficult
- DTPA can still remove radioisotopes *days to weeks* after internal contamination
 - Do not withhold even after 24 hours

http://www.akorn.com/documents/pentate/product_info/ca_zn_dtpa_sell_sheet.pdf



Radiation Medical Countermeasures Prussian blue

- FDA-approved binding agent
- For treatment of internal contamination with radioactive cesium and radioactive (and non-radioactive) thallium
- Stockpiled in SNS
- Taken orally, three times a day



Radiation Medical Countermeasures Prussian blue



- Give as soon as available
- No known contraindications
 - Overdose not been described
- Can cause constipation
- Do not exclude pregnant and nursing women from treatment



Radiation Medical Countermeasures Limitations of Treatment

- KI, DTPA, & Prussian blue CANNOT
 - Prevent radioisotopes from entering the body
 - Be used to treat all radioisotopes
 - i.e., countermeasures are isotope specific
 - Treat or reverse adverse effects caused by radioisotopes that have already entered the body
 - Treat Acute Radiation Syndrome (ARS)



<http://remm.nlm.gov>

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Exposure

- Exposure:
 - All or part of the body absorbs penetrating ionizing radiation from source external to the body
 - Exposure stops when
 - Person leaves the area
 - Source is completely shielded or removed
 - Process causing exposure ceases



Exposure



- Individuals with radiation exposure from external source
 - When scanned with a radiation survey meter will not have radiation levels above background
 - Are neither radioactive nor contaminated
 - May be approached without risk

<http://www.bt.cdc.gov/radiation/justintime.asp>



Exposure

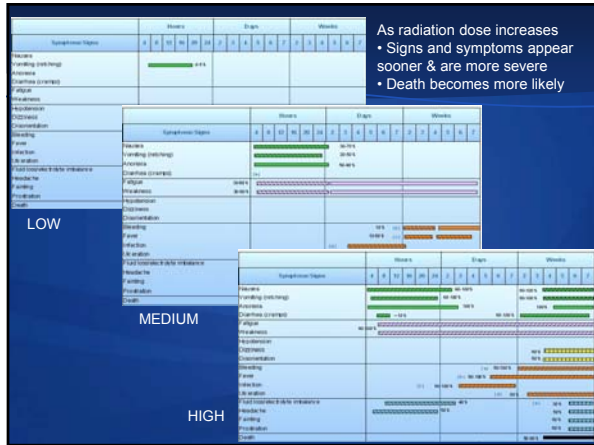
- Exposure:
 - Also may occur after internal contamination
 - Radionuclide is ingested, inhaled, absorbed
 - Exposure stops only when radionuclide totally eliminated



Victim Management: Exposure

- Handle threats to life and limb first
 - Rescue, transport, and deliver definitive care to acutely ill and injured before managing radiation exposure
- Some populations more adversely affected by high dose radiation exposure
 - Children, elderly, persons with underlying disease
 - Burn and trauma patients (Combined Injury)





Victim Management: Exposure



- Significant exposure puts people at risk for Acute Radiation Syndrome (ARS)
- ARS: Systemic illness caused by high dose, whole-body radiation exposure
- Target organ systems
 - Bone marrow
 - Gastrointestinal tract ☠
 - Neurovascular system ☠
 - Skin



ARS Prodrôme

- Begins after exposure
- Lasts 24–48 hours
- More rapid symptom onset implies greater radiation dose
- Prodromal signs and symptoms appear sooner with more severe ARS than with more mild ARS



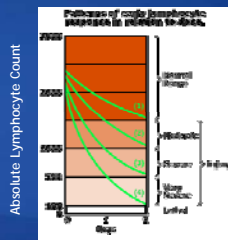
ARS Prodrôme – Signs & Symptoms

- Nausea/vomiting
 - Hallmark finding but not always present or reliable
 - Time to vomiting may be used as rough estimate of exposure and ultimate outcome
- Fever
- Fatigue
- Headache
- Salivary gland inflammation
- Diarrhea (bad sign)
- Skin redness



ARS Prodrôme – Laboratory Findings

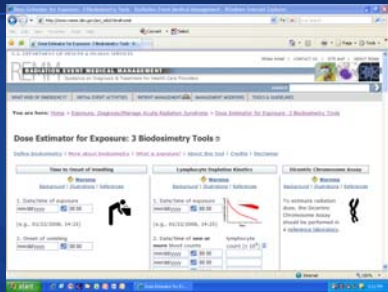
- Lymphocytes
 - Highly radiosensitive
 - Progressive decline in absolute lymphocyte count provides early estimate of injury and outcome



Andrews, et al. [1965] Personal Dosimetry for Radiation Accidents. Vienna: IAEA.



ARS Prodrôme – Dose Estimator



http://www.remm.nlm.gov/ars_wbd.htm



Radiation Medical Countermeasures Neupogen® (Filgrastim)

- Belongs to a class of drugs known as “colony stimulating factors”
- Stimulates remaining bone marrow to produce mature infection-fighting white blood cells



Radiation Medical Countermeasures Neupogen® (Filgrastim)



- Stockpiled with SNS
- Not FDA-approved for treatment of bone marrow suppression *following acute radiation exposure*
- Would be administered as an Investigative New Drug (IND) or under Emergency Use Authorization (EUA) from FDA
- CDC currently holds both the IND & EUA applications with FDA



Radiation Medical Countermeasures Neupogen® (Filgrastim)

- Not all radiation exposure victims will benefit from Neupogen
 - Lower levels of radiation exposure may not completely suppress bone marrow
 - Persons receiving very high doses of radiation
 - Persons with conventional trauma or burns plus radiation exposure (combined injury)

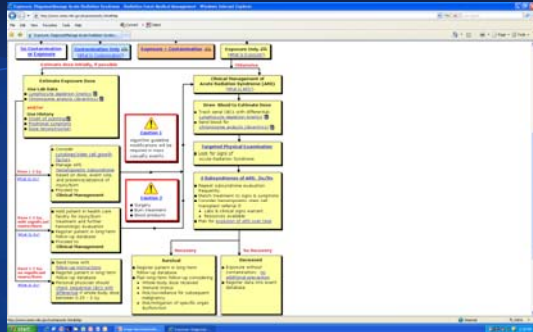


Radiation Medical Countermeasures Neupogen® (Filgrastim)



- Expected need will be based on how many have survivable radiation exposure
- Victims with non-survivable ARS still require medical care
 - Pain medication
 - Basic medical and nursing care
 - Counseling, pastoral, and psych care





<http://remm.nlm.gov>



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 - iPhone app (coming soon)



THANK YOU!



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