Radiation Injury

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Tissue Damage

- Cell cycle dependent injury
  - Mature cells limited damage
    - Lethal exposure - CNS
  - Cells with rapid cycle activity ↑ in damage
    - Hematopoietic Cells
    - Mucosal tissues
      - Gastrointestinal
      - Respiratory

Expected Outcomes Associated with Whole Body Radiation

- 0.2-1.0 Gray (20-100 RAD): Change in relative numbers of circulating leukocytes
- 2-4 Gray (200-400 RAD): Severe reduction in circulating leukocytes; nausea and vomiting; loss of hair; and death possible within 2 months due to infection
- 6-10 Gray (600-1,000 RAD): Destruction of bone marrow; diarrhea; 50% mortality rate within 1 month
- 10-20 Gray (1,000-2,000 RAD): Gastrointestinal ulceration; death within 2 weeks
- >20 Gray (>2,000 RAD): Severe damage to central nervous system; death within hours

Table 1. Acute Radiation Syndromes

Whole Body Radiation from External Radiation or Internal Absorption

Phase	Feature	Subclinical range		Sublethal range		Lethal range	
		0-100 rad (cGy)	100-200 rad (cGy)	200-600 rad (cGy)	600-800 rad (cGy)	600-3000 rad (cGy)	>3000 rad (cGy)
Prodromal Phase	Nausea and Vomiting	none	5-50%	50-100%	75-100%	90-100%	100%
	Onset		3-6 hrs	2-4 hrs	1-2 hrs	<1 hr	<1 hr
	Duration		<24 hrs	<24 hrs	<48 hrs	<48 hrs	<48 hrs
	Lymphocytes			<100 @24 hr	<500 @24 hr	<500 @ 24 hr	<500 @ 24 hr
Latent Phase	Duration	>2 wks	7-15 days	0-7 days	0-2 days	None	
Illness Phase	Sign and Symptoms	none	moderate leukopenia	severe leukopenia, purpura, hemorrhage, infection		diarrhea, fever, electrolyte disturbance	convulsions, ataxia, tremor, lethargy
	Onset		>2 wks	2 days - 2 wks		2-3 days	1-48 hrs
	Organ System	none		hematopoietic and respiratory (mucosal) systems		GI tract, mucosal systems	CNS
	Hospitalization	0	<5% 45-60 days	90% 60-90 days		100% 90+ days	100% 2 weeks
	Fatality	0%	0%	0-80%	90-100%	90-100%	
	Time of Death			3 wks-3 months		1-2 wks	1-2 days

Types of Ionizing Radiation

- Two Types:
  - Mass (alpha, beta, protons, etc.)
  - Energy (gamma and x-rays)

Types of Ionizing Radiation

- Alpha Particles:
  - Large, highly charged with limited penetration
- Beta Particles:
  - Positive electrons +
  - Negative electrons –
  - Tissue penetration – 1 cm
- Gamma:
  - Neither mass nor charge
  - Deep penetration
  - Once removed from source ↓ risk
- Neutron:
  - Nuclear reactors
  - Penetrates deeply
  - Widespread tissue damage

Accident Types

- X-ray or gamma rays
  - Risk contained to patient exposed
  - Small dose exposure
    - Does not affect health for many years
    - Associated with a few acute problems
    - Still a significant health risk
- Radioactive Contamination
  - Particulate radioactive materials (alpha)
  - Emit radiation over time
  - Risk – inhalation or ingested

Skin Changes

- 3 Gray (300 RAD)
  - Erythema
- 10-20 Gray (1,000-2,000 RAD)
  - Transdermal Injury
- 20 Gray (2,000 RAD)
  - Radionecrosis

Radiation Burn

- Typically localized
- Dose related – affected areas
- Appears identical to thermal burn
- Thermal vs. radiation
  - Time of exposure to clinical manifestations of skin changes
    - Rapid appearance = Thermal
    - Late = Radiation
- Treatment symptomatically based
- Symptoms prognosticator of exposure dose

Radiation Accidents

- Decontamination
- External contamination
- Internal contamination
- Patient transfer
- Staff decontamination and exit

External Contamination

- Chemical or Thermal Burns
  - Treat as non-contaminated burn
- Radiation Exposure
  - Skin Wounds
    - Presume contaminated
    - Initially treat site of contamination then continue with intact skin
    - Irrigation
    - Remove embedded fragments
    - Eyes – copious irrigation

Internal Contamination

- Percutaneous absorption of Iodine and Tritium
  - Emetics, laxatives, antacids to inhibit absorption
  - Diuretics – urinary excretion
    - Chlorine
    - Potassium
    - Sodium
    - Tritium

Dispersal of Radioactive Substances

- Accidents during storage
- Mishandling
- Accidents during transportation of radioactive materials
- Intentional dispersal
  - Alone or combination with other agents
- Intentional dispersal
  - Explosive device

Accidental Radiation Exposure

Haroutune Daghlian: America's first peacetime atomic bomb fatality.

Physicist with the Manhattan Project accidentally irradiated himself with 510 rem of neutron irradiation on August 21, 1945, during a critical mass experiment at Los Alamos National Laboratory, resulting in his death 25 days later.

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Radiation Burn

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Case: Yanago, Peru Incident

- Ir-192 industrial radiography source
- 1.37 TBq (37 Ci) of activity
- Worker found the source and put it in his pocket.
- Put in pocket at 16:00 and felt pain at 22:30 when he got home
- Went to see doctor – initially diagnosed as an insect bite

2/22/99
48 hours after exposure
Blistering occurs

3/1/99
Day 9
Superficial erosion of tissues

3/15/99
21 days after exposure
Additional skin peeling
at margins of exposure

3/19/99
Day 25
Infection of wound

5/3/99
73 days after exposure

10/18/99
8 months

12/14/99
10 months after exposure
Infection and necrosis spreading to perineum and other thigh

Case: Evaporator Discharge

History:

An evaporator, designed to decrease the volume of radioactive sludge that accumulates from cleaning contaminated equipment is shut down for maintenance. The worker begins on the evaporator that is still in operation.


DISPOSA-

Case: Evaporator Discharge

Treatment:

Treated as a burn victim
Fluid replacement (Parkland formula)
Morphine for pain
Foley catheter - to watch urine output
NG tube - for nausea
Chest X-Ray
Clinical Labs

Case: Evaporator Discharge

Samples Obtained:

- ✓Nasal Smears
- ✓Oral Swabs
- ✓Nostrils
- ✓Ears
- ✓Skin
- ✓Eschar
- ✓Dressings
- ✓Clothing

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Case: Evaporator Discharge

Bioassay Data:

Small quantities of Co-58, Co-60 and Mn-54
Primarily cleared through stool
Traces of Co-58 and Co-60 found in urine

Case: Evaporator Discharge

Sludge Analysis:

228 F Degrees
pH: 11.0

Isotopes:
Mn-54
Co-58
Co-60
Cr-51
Fe-59

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Burn injuries

- Are not like other trauma injuries
- Require lengthy course of treatment;

  Patient with 50% BSA = 50 ICU days
- Average burn > 50% BSA in most mass casualties

Signs of Trauma and the Occurrence of Blast Lung Injury (BLI)

Signs of Trauma	Survivors with BLI	Survivors w/o BLI	Odds Ratio	P Value
Penetrating wounds to head or torso	26.7%	8.3%	2.2 – 7.6	< .001
Penetrating wounds to extremities	10.0%	7.6%	0.7 – 2.9	.30
Burns covering more than 10% of BSA	18.3%	1.9%	5.0 – 26.9	<.001
Tympanic membrane rupture	10.0%	9.1%	0.6 – 1.9	.76
Skull fractures	23.3%	0.5%	17.7 – 176.5	<.001
Extremity fractures	13.3%	13.1%	0.5 – 2.2	.99

Almogy et al-2005

Relationship Between External Signs of Trauma and Mortality at the Scene

All Attacks

Signs of Trauma	Dead	Wounded	Odds Ratio
Open fractures	36.6%	3.0%	11.0 – 31.4
Amputations	41.2%	1.3%	25.5-98.5
Burns	49.0%	12.9%	4.4 – 9.5

Almogy et al-2005

Relationship Between External Signs of Trauma and Mortality at the Scene

Attacks Inside Buses

Signs of Trauma	Dead	Wounded	Odds Ratio
Open fractures	22.1%	1.5%	6.0 – 54.6
Amputations	41.1%	0.8%	21.1 – 383.0
Burns	47.4%	6.5%	6.8 – 24.3

Almogy et al-2005

Summary Radiation Injury

- Typically localized
- Dose related – affected areas
- Appears identical to thermal burn
- Thermal vs. radiation
  - Time of exposure to clinical manifestations of skin changes
    - Rapid appearance = Thermal
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- Treatment symptomatically based
- Symptoms prognosticator of exposure dose
- Treat Associated Injuries and Triage

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