CLINICAL MANIFESTATIONS AND MANAGEMENT OF IONIZING RADIATION EXPOSURE

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OBJECTIVES

- RECOGNIZE RADIATION PRODROMAL SYMPTOMS
- IDENTIFY THREE ACUTE RADIATION SYNDROMES
- UNDERSTAND BASIC CONCEPTS OF EXPOSURE AND CONTAMINATION
- APPRECIATE THAT A VARIETY OF INJURY PATTERNS ARE POSSIBLE AND WHY THIS IS SO
OBJECTIVES

- IDENTIFY TWO ASSESSMENT METHODS TO OBJECTIVELY QUANTITATE DEGREE OF RADIATION EXPOSURE
- BECOME FAMILIAR WITH GENERAL TREATMENT APPROACHES
- KNOW THREE DELAYED EFFECTS OF IONIZING RADIATION
ROUTES OF EXPOSURE

- THERMONUCLEAR DETONATION
- THE DIRTY BOMB
- CONTAMINATION OF FOOD/WATER
- AEROSOL
- SOURCE EXPOSURE
- OTHER
COMPLICATING FACTORS

- CHEMICAL AGENTS
- INFECTIOUS AGENTS
- TRAUMA
- FEAR
THE ACUTE RADIATION SYNDROMES AND THEIR MANAGEMENT

- KEY UNDERLYING PATHOPHYSIOLOGY AT THE CELLULAR AND ORGAN LEVEL
- DESCRIPTIONS OF SYNDROMES
- DIAGNOSTIC PROCEDURES
- CLINICAL CARE
RADIOSENSITIVITY (MOST TO LEAST)

- LYMPHOCYTES
- ERYTHROBLASTS
- MYELOBLASTS
- EPITHELIAL CELLS (INTESTINAL CRYPTS, TESTIS, OVARY, SKIN, SECRETORY GLANDS, LUNGS AND BILE DUCTS)
- ENDOTHELIAL CELLS
- CONNECTIVE TISSUE CELLS
- TUBULAR CELLS OF KIDNEY
- BONE CELLS
- NERVE CELLS MUSCLE CELLS
PRODROMAL SIGNS
SYMPTOMS

• ANOREXIA
• NAUSEA
• VOMITING
• DIARRHEA
• FEVER
• CONJUNCTIVITIS
• SKIN ERYTHEMA
PRODROMAL APPEARANCE TIME

TIME AFTER EXPOSURE (HOURS)

PRODROMAL REACTION %

- 300RADS
- 200RADS
- 150RADS
- 100RADS

TIME AFTER EXPOSURE (HOURS)
# Radiation Injury Groups

<table>
<thead>
<tr>
<th>#</th>
<th>Symptoms</th>
<th>cGy</th>
<th>Syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Asymptomatic or minimal prodrome manifest</td>
<td>0-50 (or 100)</td>
<td>Latent</td>
</tr>
<tr>
<td>2</td>
<td>Mild transient prodromal and blood count changes to severe</td>
<td>100-400</td>
<td>Hematologic mild to severe</td>
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<tr>
<td>3</td>
<td>Major hematologic complications and some GI symptoms</td>
<td>400-800</td>
<td>Hematologic severe and possible death</td>
</tr>
<tr>
<td>4</td>
<td>Gastrointestinal complications</td>
<td>800-1500</td>
<td>Gastrointestinal death</td>
</tr>
<tr>
<td>5</td>
<td>CNS-cardiovascular collapse</td>
<td>&gt;1500</td>
<td>Neurovascular complications resulting in death</td>
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</tbody>
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HEMATOPOIETIC SYNDROME
SYSTEMIC EFFECTS

- IMMUNODYSFUNCTION
- INFECTION COMPLICATIONS
- HEMORRHAGE
- ANEMIA
- IMPAIRED WOUND HEALING
EFFECTS OF GASTROINTESTINAL SYNDROME

- MALABSORPTION
- ILEUS (VOMITING AND ABDOMINAL DISTENSION)
- FLUID AND ELECTROLYTE SHIFTS (DEHYDRATION, ACUTE RENAL FAILURE, CARDIOVASCULAR)
- GI BLEEDING
- SEPSIS (SEVERE SYSTEMIC INFECTION)
- A LATENT PERIOD OF 4-5 DAYS TO WEEKS
- ACUTE 6 -8 Gy EXPOSURE IS SUFFICIENT
CLINICAL EFFECTS OF THE NEUROVASCULAR SYNDROME

- VOMITING AND DIARRHEA WITHIN MINUTES
- CONFUSION AND DISORIENTATION
- SEvere HYOTENSION
- HYPERPYREXIA (ELEVATED BODY TEMPERATURE)
- CEREBRAL EDEMA
- CONVULSIONS – COMA
- FATAL WITHIN 24 – 48 HOURS
450 cGy (Rads) Exposure
PERIPHERIAL BLOOD LYMPHOCYTE COUNT AND RADIATION EXPOSURE

• A 50% DROP IN PERIPHERIAL BLOOD LYMPHOCYTE COUNT INDICATES A SIGNIFICANT EXPOSURE

• POTENTIALLY LETHAL CASES OF BONE MARROW SUPPRESSION MAY BEGIN AT 3 WEEKS AFTER EXPOSURE, OR NOT OCCUR UNTIL 7-8 WEEKS AFTER EXPOSURE
Cytogenetics and dose estimate

In Vitro γ Ray Dose Response Curve
For Human Lymphocytes

192Ir γ

Dicentrics/Cell

Dose (Rads)
TREATMENT OF THE ACUTE NON-CONTAMINATED RADIATION EXPOSURE VICTIM

- LD50/60 IS APPROX 3.5 Gy (UNTREATED)
- CONVENTIONAL THERAPY FOR NEUTROPENIA
- CYTOKINES (EFFECTIVENESS IS TIME DEPENDENT)
- EARLY WOUND CLOSURE
- 36-48 HOUR WINDOW FOR SURGICAL INTERVENTIONS
EXTERNAL CONTAMINATION

• NEGLIGABLE RISK TO HEALTH CARE PROVIDER

• BETA EMITTERS WHEN LEFT ON THE SKIN WILL CAUSE SIGNIFICANT BURNS AND SCARRING

• ALPHA RADIATION DOES NOT PENETRATE THE EPITHELIELUM
RADIATION DERMATITIS

- 600-2,000 REM (cSv)  ERYTHEMA ONLY
- 2,000-4,000 REM (cSv) SKIN BREAKDOWN IN 2 WEEKS
- >300,000 REM(CsV)  IMMEDIATE SKIN BLISTERING
- CHRONIC RADIODERMATITIS ASSOCIATED WITH > 20,000
INTERNAL CONTAMINATION

- INHALATION (SIZE DEPENDENT DEPOSITION CHARACTERISTICS)
- INGESTION (CAN INCLUDE INHALED SUBSTANCES AS MUCOCILIARY TRANSPORT AND SWALLOWING TAKE PLACE)
- WOUND CONTAMINATION
- SKIN ABSORPTION
DISTRIBUTION AND METABOLISM OF RADIOACTIVE SUBSTANCES

- SUBSTANCES ARE HANDLED BASED ON THEIR PHYSIOCHEMICAL MAKEUP
- FOR EXAMPLE FOLLOWING INGESTION:
  - RADIOIODINE, CESIUM, AND STRONTIUM ARE RAPIDLY ABSORBED
  - IODINE SEEKS A THYROID TARGET
  - CESIUM FOLLOWS POTASSIUM AND TARGETS THE KIDNEY
  - STRONTIUM BEHAVES LIKE CALCIUM AND IS DEPOSITED IN A PRIMARY TARGET OF BONE
MORE EXAMPLES

- PLUTONIUM METAL IS POORLY ABSORBED AND WOULD BEHAVE AS SUCH AND BE A LOCAL RADIATION SOURCE WHERE 5 MICRON PARTICLES WOULD POSE A THREAT TO PULMONARY TISSUE IF INHALED AND THE GI TRACT IF INGESTED

- PLUTONIUM SALTS ARE EASILY ABSORBED AND WOULD REQUIRE A DIFFERENT TREATMENT
ASSESSMENT AND TREATMENT

- STABILIZE LIFE THREATENING CONDITIONS
- DECONTAMINATE WITH PRACTICAL CONSIDERATION
- COLLECT APPROPRIATE BLOOD AND BODY FLUID FOR ANALYSIS
- AN EDTA BLOOD SAMPLE IS MOST ESSENTIAL.
- NASAL SWABS, URINE, AND STOOL SAMPLES WHERE INDICATED AND PRACTICAL
INTERNAL DECONTAMINATION

- DISPLACEMENT (USEFUL WITH RADIOIODINE AND STRONTIUM FOR EXAMPLE: COLD IODINE AND CALCIUM COMPETE FOR THEIR DEPOSITION)
- DILUTION (TRITIUM FOR EXAMPLE: SIMPLE HYDRATION)
- UPTAKE INHIBITION (PRUSSIAN BLUE FOR CESIUM)
- CHELATION (DTPA FOR PLUTONIUM)
SURVEY AND ASSESSMENT OF PATIENTS BY A RADIATION HEALTH PHYSICIST IS ESSENTIAL TO PERMIT OBJECTIVE RISK ASSESSMENT AND STRATEGIC PLANNING
DELAYED EFFECTS OF HIGH DOSE IONIZING RADIATION EXPOSURE

• IN UTERO EXPOSURE LEADS TO DOSE DEPENDENT INCREASE IN MENTAL RETARDATION AT 8-15 WEEKS GESTATION AND LESS SO FOR 16-25 WEEKS. THIS IS NOT OBSERVED <8 AND >25 WEEKS

• PARENTAL EXPOSURE DOES NOT REVEAL OVERT EFFECT ON THEIR OFFSPRING
• ACUTE EXPOSURE TO AS LITTLE AS 2 Sv CAN LEAD TO CATARACT FORMATION WHICH CHARACTERISTICALLY BEGINS BETWEEN 6 MONTHS AND SEVERAL YEARS AFTER EXPOSURE. INCIDENCE IS DOSE RELATED. THIS IS A DETERMINISTIC EFFECT.

• INCIDENCE OF LEUKEMIA AND THYROID CANCER (PARTICULARLY IN CHILDREN) IS INCREASED BUT DIFFICULT TO QUANTITATE. THIS IS A STOCHASTIC EFFECT.
SUMMARY

• LIFE THREATENING CONDITIONS ARE ADDRESSED PROMPTLY AND STANDARD UNIVERSAL PRECAUTIONS ARE ADEQUATE WHEN WE BALANCE THE MINIMAL RISK TO THE HEALTH CARE PROVIDER AGAINST PATIENT CARE PRIORITIES

• DECONTAMINATE PROMPTLY (SIMPLE CLOTHING REMOVAL IS A MAJOR PORTION OF THIS JOB)
SUMMARY

• IF SCREENING REVEALS RADIOISOTOPE INVOLVEMENT A RADIATION HEALTH PHYSICIST IS PROMPTLY NEEDED TO QUANTITATE AND CHARACTERIZE EXPOSURE

• RECOGNIZE THE IMPORTANCE OF APPROPRIATE SPECIMEN COLLECTION AND THE ROLL IT PLAYS IN OBJECTIVE ASSESSMENT
• RECOGNIZE NEED TO ACQUIRE MORE KNOWLEDGE SO AS TO BE PREPARED TO COMMUNICATE WITH PUBLIC HEALTH OFFICIALS, PATIENTS AND COLLEAGUES EFFECTIVELY