Nuclear Plant Emergency Response

Acute and Chronic Clinical Health Effects after a NPP Accident

Module 5

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At the end of this presentation you will be able to:

- Discuss the initial medical evaluation of a patient who was injured while in proximity to the reactor.
- Discuss the initial medical evaluation of someone who was evacuated from the neighboring community.

Stochastic Effects versus Deterministic Effects

- Deterministic effects occur at or above a threshold dose,
  - reddening of skin (erythema)
  - cataracts
- Stochastic effects are those that occur randomly
  - cancer
  - effects in offspring

Medical Hazards from Radiation

- At the NPP site:
  - High levels of radiation
    - Risk of exposure to penetrating radiation acutely
    - Risk of contamination
- In the surrounding area:
  - Risk of contamination and long term effects:
    - Inhalation
    - Food and Water
    - Milk

At the NPP Site

"The workers were laying cables Thursday in the basement of the reactor's turbine building when they stepped in the water. It seeped into the ankle-height boots of two of the men, according to Tokyo Electric Power Company, which operates the plant." CNN

Tokai Mura Accident

Worker 1

- Estimated dose 12 Sv.
- Lost consciousness a few minutes after the explosion and then began to vomit.
- He recovered consciousness 70 minutes later and had diarrhea.
- He developed acute radiation syndrome.
- Received Bone Marrow Transplant (sister).
- Died 3 months later.

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Tokai Mura criticality accident

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Worker 2

- Estimated dose
  7-8 Sv.
- Vomited after an hour.
- Developed acute radiation syndrome.
- Survived almost one year.

Source JAEA

Worker 3

- Estimated dose 1.6 Sv.
- Was in an office 10-20 m away.
- Asymptomatic. Only mild nausea.
- Survived.

Clinical Consequences of Internal Contamination

- Primarily Chronic
  - Solid tumors (Thyroid)
  - Leukemias
- Acute and subacute
  - End organ damage
  - Acute Radiation yndrome
  - Multiorgan failure

Diagnosis of Internal Contamination: Direct Bioassay

- After external decontamination is completed.
- Sensitive detector.

Diagnosis of Internal Contamination: Excretion (Bioassay) Sampling

- Collect urine to measure radioactivity.
- Challenging interpretation
  - Time when contamination occurred
  - Characteristics of inhaled or internalized radionuclides

http://www.bt.cdc.gov/radiation/labinfo.asp

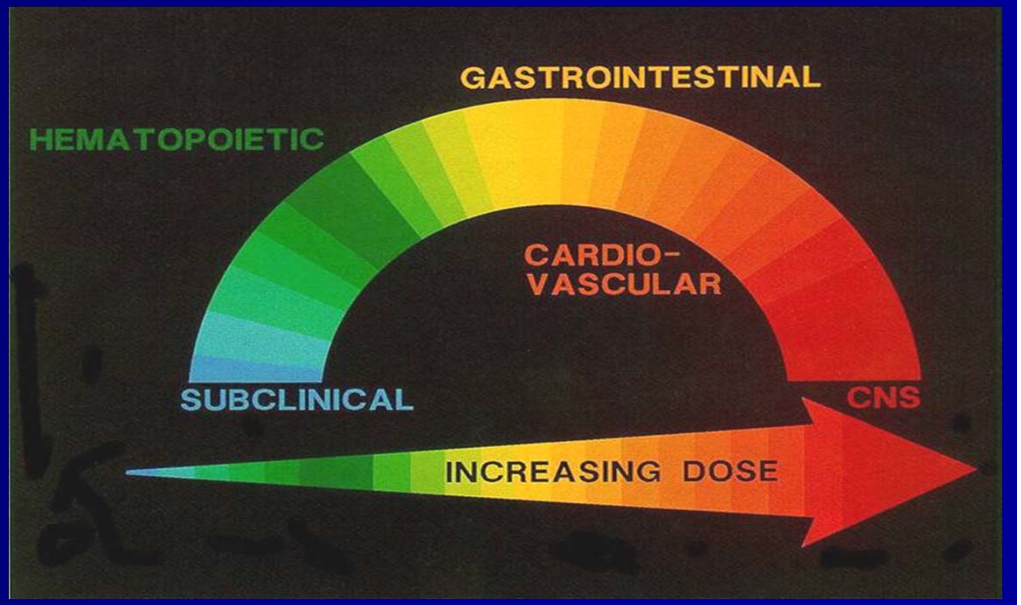
EVALUATION OF POSSIBLE EXPOSURE TO RADIATION

Initial Evaluation

- Radiation detection.
  - Decontamination may not be necessary if patients were exposed to radiation but not contaminated.
- Significant exposure usually can occur in close proximity to the reactor.
  - NPP and rescue workers (e.g., firefighters).
  - Can be measured using personal dosimeters..

Acute Radiation Syndrome (ARS)

- Deterministic effect
- Prodrone phase
- Hematopoetic syndrome
- Gastrointestinal syndrome
- CV/CNS syndrome



Prodrome

- Vague Sx: nausea, vomiting, headache.
- Help predict the dose: the higher the absorbed dose the earlier and the more frequent the Sx occur.
- LD 50/60 without treatment is 6 Gy.
- LD 50/60 with treatment is 8 Gy.
- LD 100/60 is greater than 10 Gy

Dose Estimate	Victims with Vomiting	Time to Onset of Vomiting
Gy	%	*h*
0	–	–
1	19	
2	35	4.63
3	54	2.62
4	72	1.74
5	86	1.27
6	94	0.99
7	98	0.79
8	99	0.66
9	100	0.56

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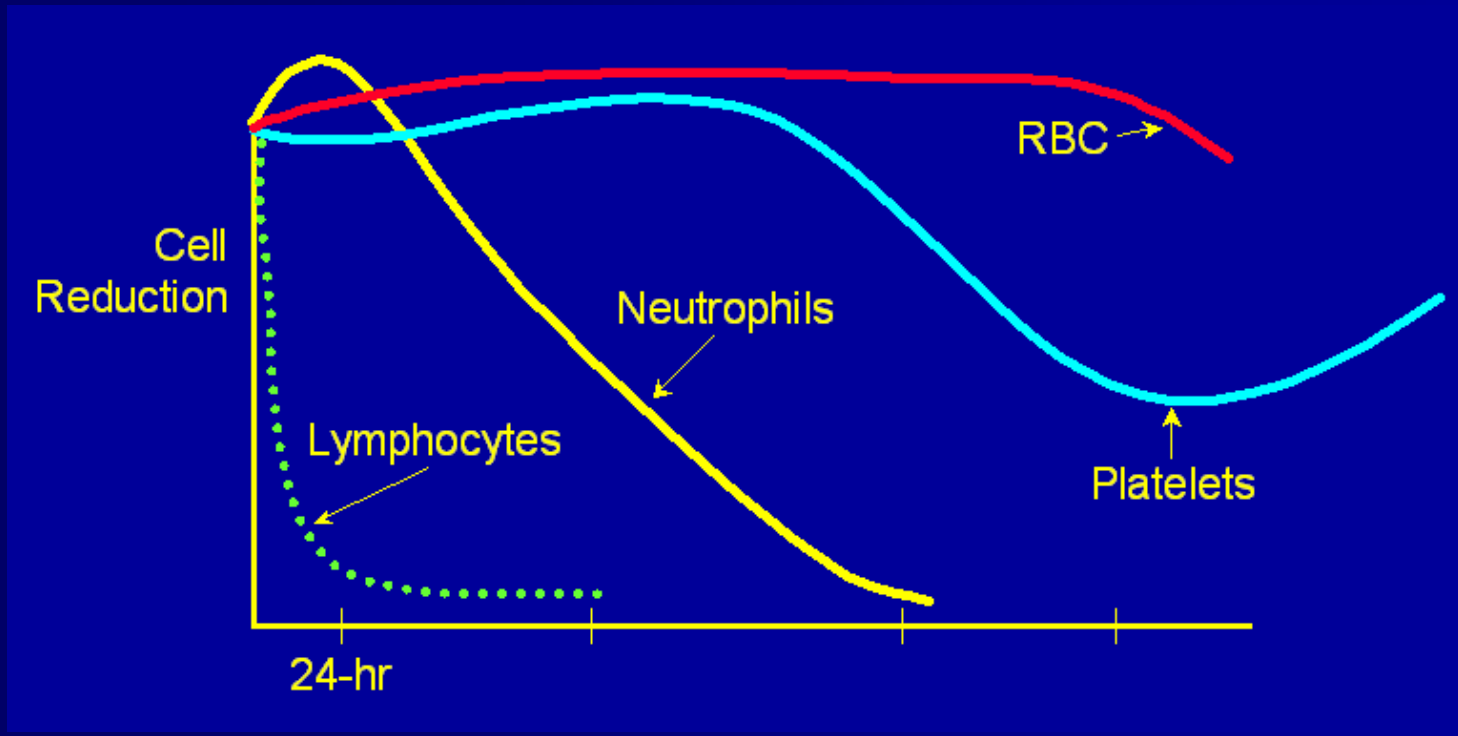
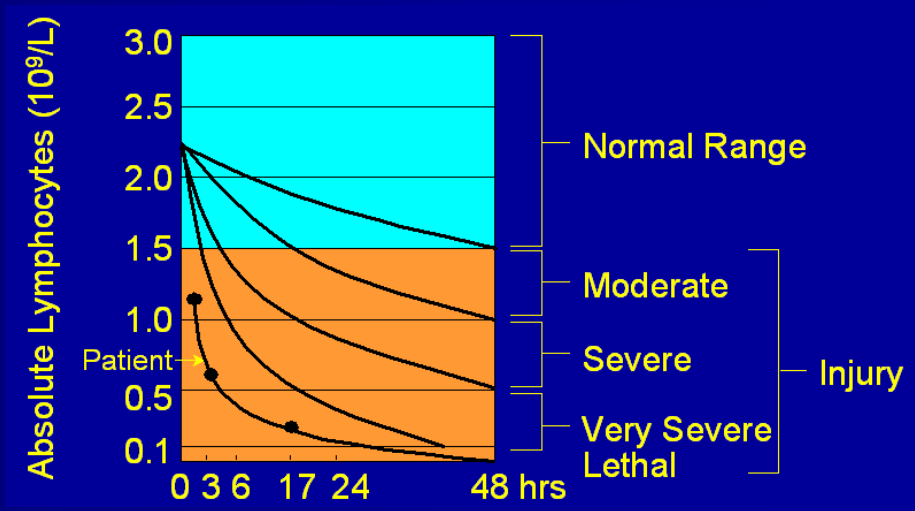
Hematopoetic Syndrome (2-6 Gy)



Lymphocyte Depletion Kinetics

- Andrew's nomogram helps estimate the dose of radiation.
- WBC with differential every 6 hrs for first 24-48 hours.



Management of the Hematopoetic Syndrome

- Complications: infection and bleeding.
- Treatment is supportive:
  - Reverse isolation
  - IVF
  - Blood products
  - Antibiotics
  - Colony stimulating factors such as filgrastim or G-CSF (300 mcg s/c per day)
  - Stem cell transplant (www.ritn.net)

In the Surrounding Area:

- Possible long term medical effects:
  - Thyroid cancer
  - Solid tumors and leukemias
- Inhalation.
- Ingestion.

Thyroid Cancer

- 5000 cases of thyroid cancer attributed to radiation from Chernobyl.
- Papillary type is the most common.
- Increased incidence in children (2-5 times baseline) and those who may have dietary iodine deficiency.

Thyroid Cancer

- Short latency: 4 years
- 30-year mortality 1%
- Recurrence 30%.

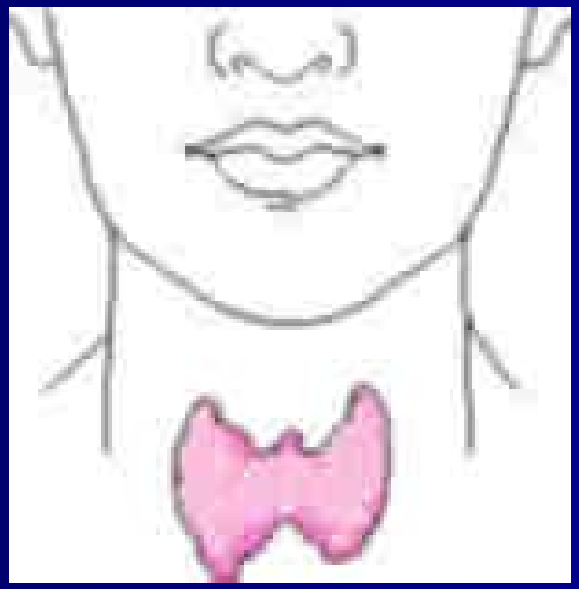
Medical Countermeasures: Potassium Iodide (KI)

KI – What is it?

- Iodide salt
- Pill or liquid
- Iodine is required by body to make thyroid hormone

Radioactive Iodine Exposure

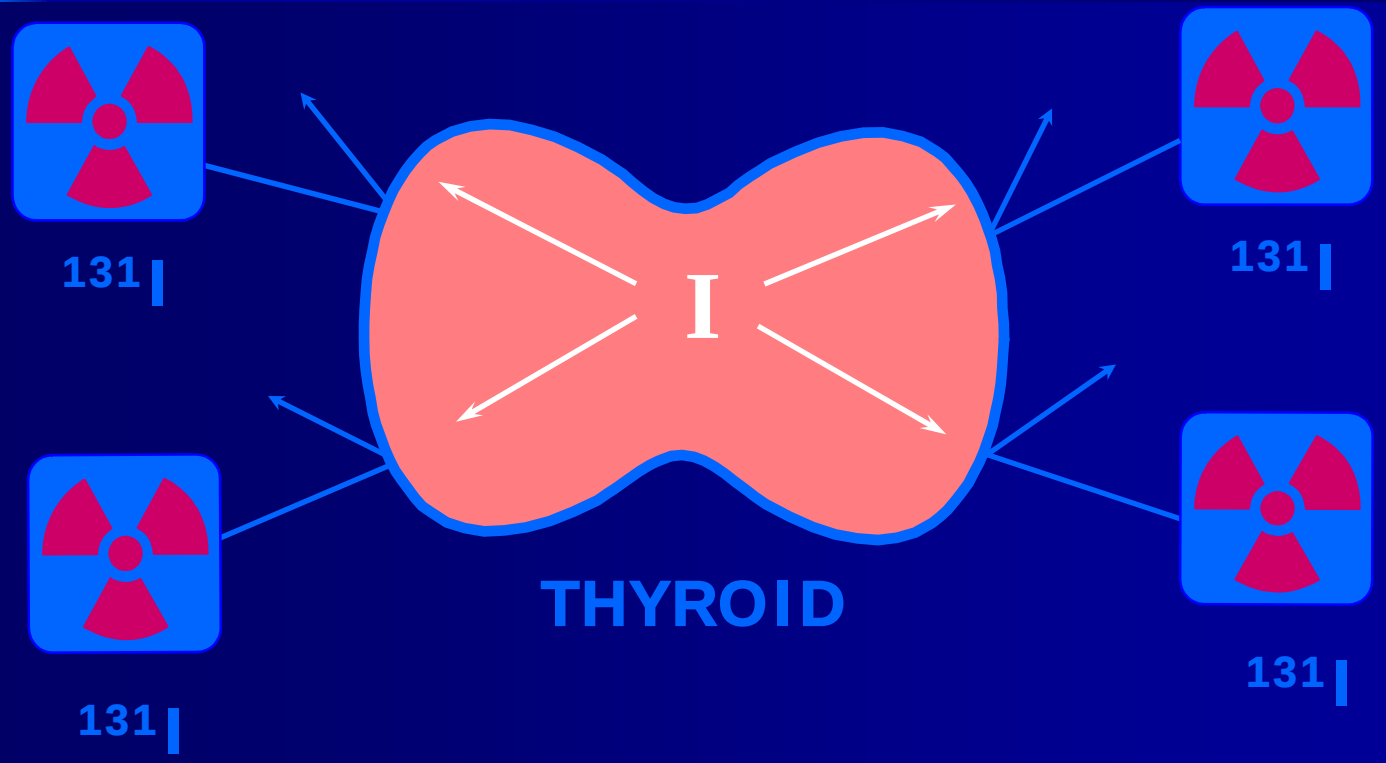
- Iodine Prophylaxis and Treatment
  - Potassium iodide (KI) is an effective thyroid-blocking agent.



KI – How Does it Protect Us?

- Blocks uptake of radioactive iodine by the thyroid gland.
- Cannot distinguish radioactive from non-radioactive.
- One dose saturates thyroid for 24 hours
- Decreases risk of thyroid cancer after internal contamination with radioiodines.

Internal Contamination with Radioactive Iodine

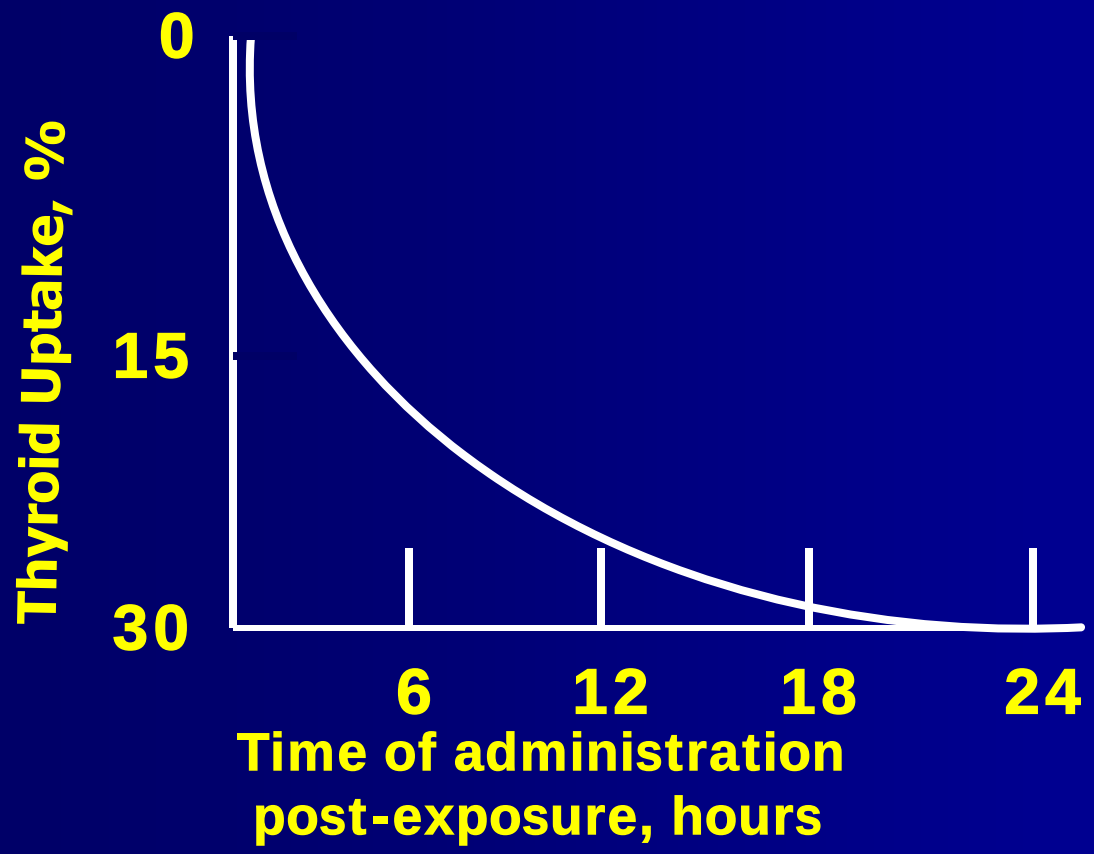


Saturate the Critical Organ with the Stable Isotope

KI – How Effective is It?

- Depends on the amount of radioactive iodine one is exposed to
- Depends on time from exposure to time of treatment

Efficacy of KI is Time Dependent



KI – Role in a NPP Accident

- Removal from the exposure pathway of 131-Iodine is the most important step. Radioactive half life is 8 days.
  - Shelter in place
  - Evacuation
  - Food, milk, and water monitoring
- Administration needs to be guided by local health authorities.
- Duration of treatment will be determined by duration of contamination risk.

US FDA-Dosing Recommendations

Threshold Thyroid Radioactive Exposures and Recommended Doses of KI for Different Risk Groups				
	Predicted Thyroid exposure(cGy)	KI dose (mg)	# of 130 mg tablets	# of 65 mg tablets
Adults over 40 yrs	≥500	130	1	2
Adults over 18 through 40 yrs	≥10			
Pregnant or lactating women	≥ 5			
Adoles. over 12 through 18 yrs*		65	1/2	1
Children over 3 through 12 yrs		32	1/4	1/2
Over 1 month through 3 years		16	1/8	1/4
Birth through 1 month				

*Adolescents approaching adult size (≥ 70 kg) should receive the full adult dose (130 mg).

KI – in children

- Liquid KI formulation is available.
- Instructions to use KI tablets to make a liquid solution are available at:
  http://www.fda.gov/Drugs/EmergencyPreparedness/BioterrorismandDrugPreparedness/ucm072248.htm
- Other iodine preparations are not FDA-approved for this purpose.

KI – What are the Side Effects?

- Rare
- Intestinal upset
- Rash
- Allergic reaction (rare)

KI – What Can't it do?

- Prevent radioactive material from entering the body.
- Reverse health effects after exposure to radioactive iodine has occurred.
- Protect from other radioactive materials.

KI – Available Products

- Iosat (65 mg and 130 mg tablets)
- ThyroSafe (65 mg tablets)
- ThyroShield (65 mg/mL solution)
- All over the counter

No Longer Available

- Sodium perchlorate
  - Reports of aplastic anemia

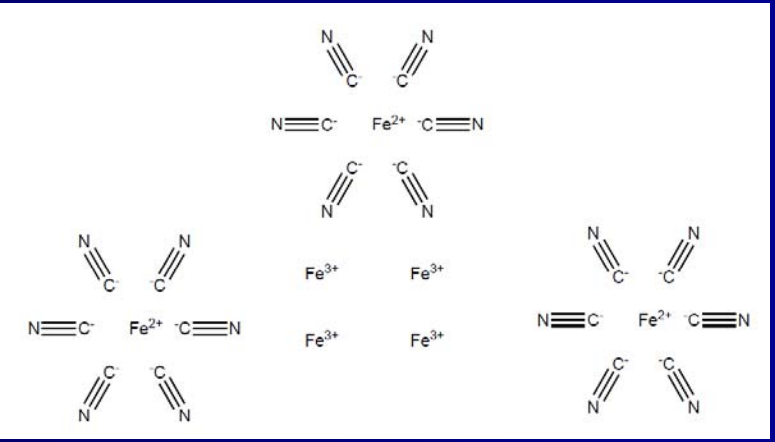
Unacceptable Preparations or Alternatives

- Iodized salt.
- Seaweed.
- Tincture of iodine.

Medical Countermeasures: Prussian Blue (PB)

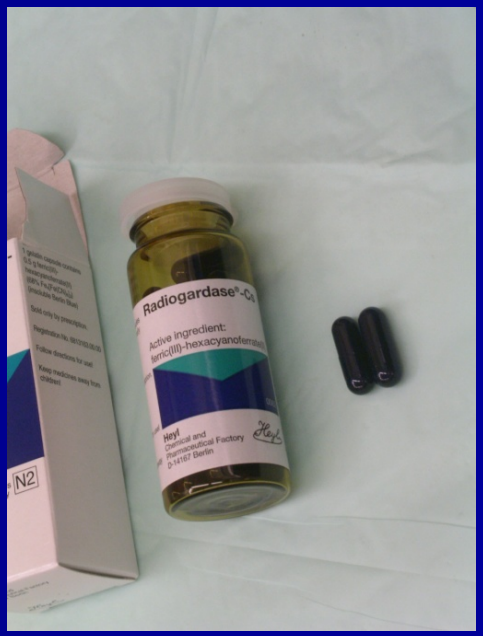
Mechanism of Action

- Exchanges a cation and binds Cesium.
- Decreases GI absorption and interrupts enterohepatic circulation.



Radiogardase®

- Insoluble form FDA approved in 2004.
- Dosage in adults is 3 g orally every 8 hours.
- Adverse effects: Constipation and blue stools, sweat, and teeth.



Prussian Blue Role in a NPP Accident

- Cesium contamination of food items like meat. Radioactive half life is 30 years.
- Food source interdiction is the main protective action.
- Prussian blue therapy is less likely but will be guided by consultation with local health authorities and estimates of body content of cesium.

Prussian Blue Availability

- Strategic National Stockpile.
- Can be purchased privately from Akorn Pharmaceuticals, Lake Forest, IL, USA (www.akorn.com, www.ca-dtpa.com)

Questions or Comments?

Summary Points

- Acute health effects can occur in very close proximity to the nuclear reactor.
- Chronic health effects are more likely to affect people living in surrounding areas.
- KI is only efficacious in preventing thyroid cancer.
- KI has to be given within 3-4 hours of exposure.

Summary Points

- Evacuation, shelter-in-place, and contamination control are the primary protective action measures.