Nuclear Accidents: What Does the Public Need to Know?

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Photo by Asahi Shimbun/Reuters
A Patient's asks

- Can I feed my children tuna fish after Fukushima? Will they get cancer?
- Does European cheese have radioactive cesium in it from Chernobyl?
- Help! Why am I being detained by airport security?
- Are polar bears suffering from fur loss and open sores due to Fukushima?
A Dirty Bomb Goes off in the Stanford Stadium ...

- As a physician working in nuclear medicine how will you respond?
What is a Radiation Accident

- A situation in which there is an unintentional exposure to ionizing radiation or radioactive contamination
- Exposure may be real or suspected
The range of potential emergencies involving ionizing radiations is enormous
- From a major reactor accident to accidents involving small amounts of radioactive material

In general, emergencies may be classified into two broad categories:
- Nuclear accidents
- Radiological accidents
Nuclear Accidents

- The term *nuclear accident (emergency)* applies to:
  - Reactor accident
  - Reprocessing plant accident (DOE-WA, NY, South Carolina)
  - Accidents at other large nuclear facilities
  - Accident involving the detonation with partial nuclear yield of a nuclear weapon

- Nuclear Accidents involve nuclear fuel and the potential for criticality
Where Can They Occur

- The most common facility containing very large amounts of radioactive material is a *nuclear power plant*
- There are >400 commercial nuclear power plants in the world
- In the US there are 65 commercially operating nuclear power plants (104 nuclear reactors) in 31 states. These plants generate about 15-20% of U.S.
- California has 2:
  - Diablo Canyon, San Luis Obispo
  - San Onofre, San Diego (shut down)
3 major reactor accidents in the history of civil nuclear power in 32 Countries

- **Three Mile Island (1979)**
  - Xenon and 13-17 Ci of I131 released. Reactor vessel maintained integrity. No deaths. No significant difference in the overall rate of cancer (NYT 11/1/02)

- **Chernobyl (1986)**
  - Explosion and intense fire without provision for containment. Large quantities of radioactive particles released. 56 deaths directly attributed to accident.

- **Fukushima (2011)**
  - Severely tested containment, some release of radioactivity. Current (9/20/13) ocean water samples show Cs-137 below WHO drinking standard. No deaths. (19,300 deaths from tsunami)

- **5000 coal mining deaths occur worldwide annually (In 2006 there were 4746 mining deaths in China alone)**
Three Mile Island – A Success Story?

- March 28, 1979 near Harrisburg, Pennsylvania
- Valve malfunction caused lost coolant with partial meltdown
- Concrete containment structure prevented radiation from escaping into the environment
- Some radioactive xenon gas, I$_{131}$ released, no fatalities
- No significant increase in cancer deaths in exposed population
- Damage largely contained
- China Syndrome released 12 days before
- Construction of new nuclear plants ↓↓ shortly after
- Resulted in broad changes in the nuclear power industry and NRC regarding: emergency response, operator training, engineering/design criteria, radiation protection, and oversight to enhance safety
Chernobyl Accident –
April 26, 1986 no containment vessel

- During a systems test there was a sudden and unexpected power surge. Emergency shutdown was attempted which led to a reactor vessel rupture
- Initial radiation released primarily I-131 (half life= 8 days), Cs-137 (half life= 30 years) and Sr-90 (half life= 28 years)
- Death Toll (IAEA): 2 workers immediately, 28 firemen from Acute Radiation Sickness and one of cardiac arrest
- Children susceptible to I-131 (Not given potassium iodide)
  - 6000 cases of thyroid cancer reported (UNSCEAR 2005)
  - No evidence of increase in solid cancers or leukemia
- Risk estimates predict an excess of cancer death at 4000 (WHO) to 5000 (Mettler)
- Scandinavian countries and other parts of the world were affected by the radioactive releases from Chernobyl.
Chernobyl Accident - Was cheese hot?

- UN report (2000)- “there is no scientific evidence of any significant radiation-related health effects to most people exposed”
- No evidence of increase in birth defects, abnormal pregnancies, or reduced fertility
- There are secondary effects-
  - fatalism, mental health problems, smoking, alcohol abuse, general poor health
- Throughout Europe, in nations where abortion is legal, many requests for induced abortions, of otherwise normal pregnancies, were obtained out of fears of radiation
- In Greece, following the accident many obstetricians were unable to resist requests from worried pregnant mothers over fears of radiation. Although it was determined that the effective dose to Greeks would not exceed 1 mSv (100 mrem)
  - there was an observed 2500 excess of otherwise wanted pregnancies being terminated (Br Med J (Clin Res Ed). 1987 October 31; 295(6606): 1100)
Chernobyl’s Agricultural Impact

- Ecosystems affected by Chernobyl have been studied and monitored extensively for two decades. Major radionuclide releases continued for ten days and contaminated more than 200,000 square kilometers of Europe.
- Most of the strontium and plutonium isotopes were deposited within 100 kilometers of the damaged reactor.
- Strontium and caesium, with a longer half-life of 30 years, persist and will remain a concern for decades.
- Deposition varied depending on whether it was raining when contaminated air masses passed.
- For the long term, Cs-137, present in milk, meat and some plant foods, remains the most significant concern for internal human exposure, but, with the exception of a few areas, concentrations fall within safe levels.
- Example of agricultural impact: Almost 26 years after the Chernobyl nuclear disaster, restrictions on the movement of sheep in Scotland and Northern Ireland were lifted in June, 2012.
Fukushima - March 11, 2011

- A consequence of 9.0 magnitude earthquake and tsunami.
- Emissions caused measurable radiation and isotope concentrations in the environment in soil, water, and foodstuffs (I-131, Cs-137, Sr-90, plutonium isotopes)
- Direct and indirect effects of the releases in Japan were measured in Europe and the US
- Measured values were far below those values that could affect human health
Evaluation of radioactivity concentrations from Fukushima in fish products

- Testing of seawater 30 km off the coast of Japan show that concentrations of radionuclides rapidly drop to very low levels.
- If individuals only consume fish products from Fukushima and adjacent prefectures in Japan there is no health concern based on monitoring data reported to date, (Cs-137 levels in 98.5% of Japanese fish products $<100$ Bq kg$^{-1}$, and fish products with cs-137 $>100$ Bq kg$^{-1}$ not allowed to enter the market).
- Some of the contaminated fish in Japanese coastal waters such as tuna and salmon can migrate to other ocean areas.
- Radioactive cesium declines when fish leave contaminated waters as cesium will gradually be excreted (biological half-life 5 -100 days).
- If cesium detected significantly below any public health concern.
- Fish products outside of Japan are safe, even for individuals with high seafood consumption.
- The polar bears are fine!

Radiological Accidents

- While a nuclear power plant incident will take time to evolve, a radiological accident such as a terrorist incident will have 'no-notice'

- A radiological accident (emergency) is one that involves
  - Sources other than nuclear fuel (e.g., cesium sealed source, industrial radiography iridium source)
  - The dispersion of material from a nuclear weapon without a nuclear yield
  - Radiological emergencies that could result from deliberate acts, such as terrorist activities or illicit trafficking
Goiânia, Brazil
Demolition of a contaminated house. The photo shows the extent of the remedial work that had to be undertaken in case of the Goiânia accident.
A private Goiânia radiotherapy institute moved leaving a Cs-137 teletherapy unit without notifying the licensing authority.

The building was partly demolished allowing 2 men to enter and remove metal from the unit for scrap value.

The Cs-13 source, in cesium chloride form, ruptured.

At the junkyard, the owner noticed the source assembly glowed.

Over the period of several days friends and relatives came to see the phenomenon.
After 5 days a number of people had GI problems from the radiation exposure. Physicists and physicians were dispatched and Olympic stadium set up for triage. 22 persons gathered. 20 persons needed medical treatment. 4 died within four weeks (6, 22, 18 and 38 year old) - whole body dose 4.5 – 6 Gy. 112,000 were monitored/249 were contaminated either internally or externally. Prussion Blue administered to 46 persons.
Accidents with Radioactive Sources – Where Can They Occur?

- Medical institutions
- Industrial facilities
- Research and educational institutions
- Transport involving radioactive material
- Nuclear fuel cycle
- Field applications with gamma radiography
- There are 2 emergency response in the US per day involving radioactive material
Possible Radiological Hazards

- External irradiation
- Internal contamination through inhalation or ingestion
Early Event Management

- If something happens at Diablo Canyon nuclear reactor, a dirty bomb scare at the Stanford Stadium during the big game, a cyclotron accident in which 5 researchers are sent to the emergency room, nuclear medicine staff may be called...
  - Nuclear medicine staff have survey meters for general surveys
  - NaI probe to measure iodine in the thyroid
  - Well counters to count loose contamination
  - Assist with walking large crowds through the SUH or SOM loading dock waste area radiation monitors
- For contamination control wear gowns and gloves
- Contaminated persons who are uninjured or have only minor injuries should be taken to a designated center for decontamination (removal of clothing and showering), and treatment of minor injuries
- Psychological symptoms mimic those of radiation exposure (nausea, vomiting, and rash), it is important to have effective triage procedures in place
The Society of Nuclear Medicine (SNM) says that, although the tiny amount of isotope (radioactive material) used in nuclear testing and treatment stays active for only a short time, it can set off devices at airport security screening checkpoints.

- A patient who has had a nuclear medicine procedure may be stopped by security personnel.
- This could cause long delays, interrogation and body searches.
- Medical information post cards used by Tahlequah City Hospital are a good idea, and that nuclear medicine patients need to communicate with airport security staff.
- Stanford uses a “Patient Information Letter”
July 9, 2013

To Whom It May Concern:

Mr/Mrs __________________ has undergone a Nuclear Medicine procedure on ______ at Stanford University Medical Center involving the administration of radioactive materials. This may trigger radioactivity alerts at various locations. The radiation received by the patient is allowed by medical use regulations.

Should you have any questions please contact the Stanford University Medical Center pager operator at 650 723 6661 and request to speak to the on-call Nuclear Medicine attending physician.

Sincerely,

___________________________, MD
An aside: Coal Power plants

- Coal-fired power plants throughout the world are a major source of radioactive material release to the environment.
- Coal combustion is more hazardous to health than nuclear power and adds to the background radiation burden more than nuclear power.
- Coal contains trace quantities of the naturally-occurring radionuclides uranium and thorium, as well as their radioactive decay products, and potassium-40. When coal is burned, minerals, including most of the radionuclides, do not burn and concentrate in the ash.
- While most ash is captured, tiny solid particles known as "fly ash," including some radionuclides, escape into the atmosphere. Current regulations focus on using technology to reduce the amount of fly ash that escapes including most radioactive particles, and on proper fly ash disposal.
- If radiation emissions from coal plants were regulated in the same was as nuclear power plants, their capital and operating costs would increase, making coal-fired power less economically competitive!
## Radiation Dose Comparisons

<table>
<thead>
<tr>
<th>Source</th>
<th>Dose (mrem)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest X-ray</td>
<td>10</td>
</tr>
<tr>
<td>5-hour plane flight</td>
<td>3</td>
</tr>
<tr>
<td>Live within 50 miles of coal-fired power plant for 1 year</td>
<td>.03</td>
</tr>
<tr>
<td>Live within 50 miles of a nuclear plant for 1 year</td>
<td>.009</td>
</tr>
<tr>
<td>US Average Natural Whole Body Radiation Dose</td>
<td>300</td>
</tr>
<tr>
<td>From 2 decades after Chernobyl – residents of contaminated areas*</td>
<td>900</td>
</tr>
<tr>
<td>First year after Chernobyl – European residents*</td>
<td>&lt;100</td>
</tr>
<tr>
<td>most affected part of Fukushima prefecture*</td>
<td>100-500</td>
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</tbody>
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* WHO estimate
Thanks...