ALARA Update for Medical Imaging

Stewart C. Bushong, Sc.D.
Baylor College of Medicine
Houston, Texas
sbushong@bcm.tmc.edu
ALARA:

At Last Another Raise Already

Any Little Annoyance Requires Attention

After Love in the Afternoon Repeat Again

As Long As Repeating Allows

As Low As Reasonably Achievable
IMPLEMENTATION
OF THE PRINCIPLE OF
AS LOW AS REASONABLY
ACHIEVABLE (ALARA)
FOR MEDICAL AND
DENTAL PERSONNEL
Cardinal Principles of Radiation Protection

- Time
- Distance
- Shielding
• X-rays: High Dose Fluoroscopy
• X-rays: Multislice Spiral CT
• γ-rays Brachytherapy
• RF: Four MRI Zones
• VL: Laser Safety
• US: QC and Indices
3 angiograms
1 angioplasty
Coronary stent placement and atherectomy
1st, 172 min...2nd 83 min
5 hr TIPS
3 TIPS
13 hr

5 months
6.5 months
9 months
10 months
11 months
3 coronary angiograms
2 angioplasties
80 min
Unsuccessful angioplasty
145 min
6 procedures
in 12 years
110 min
<table>
<thead>
<tr>
<th>Effect</th>
<th>Single-dose threshold ($Gy_t$)</th>
<th>Approximate Onset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early transient erythema</td>
<td>2</td>
<td>2 - 24h</td>
</tr>
<tr>
<td>Main Erythema</td>
<td>6</td>
<td>10 d</td>
</tr>
<tr>
<td>Temporary epilation</td>
<td>3</td>
<td>3 wk</td>
</tr>
<tr>
<td>Permanent epilation</td>
<td>7</td>
<td>3 wk</td>
</tr>
<tr>
<td>Dry desquamation</td>
<td>14</td>
<td>4 wk</td>
</tr>
<tr>
<td>Moist desquamation</td>
<td>18</td>
<td>4 wk</td>
</tr>
</tbody>
</table>
Ten Commandments for Minimizing Risks from Fluoroscopic X-Rays

• #1 Remember, dose rates will be greater and dose will accumulate faster in larger patients.

• #2 Keep the tube current as low as possible.

• #3 Keep the kVp as high as possible.

• #4 Keep the patient at maximum distance from the x-ray tube.

• #5 Keep the image intensifier as close to the patient as possible.

• #6 Don’t overuse geometric or electronic magnification.

• #7 If image quality is not compromised, remove the grid.

• #8 Always collimate to the area of interest.

• #9 Personnel must wear protective aprons, use shielding, monitor their doses, and know how to position themselves.

• #10 Keep beam-on time to an absolute minimum!
   – The Golden Rule
20 min — REPORT
60 min — STOP!
Modulation of Radiation Injury

C. Norman Coleman, Helen B. Stone, John E. Moulder, Terry C. Pellmar

Ionizing radiation is present all around us, exposure to background radiation from cosmic rays and naturally occurring isotopes is unavoidable. We are exposed during diagnostic and therapeutic medical procedures and in certain occupations. Radiation therapy for cancer allows for precise, focused delivery, with improved quality of life; nonetheless, some exposure of normal tissue is unavoidable. As a result, many millions of cancer survivors will live for decades but will be at risk for adverse consequences such as tissue atrophy and secondary tumors (1).

Further, the devastating events of 11 September 2001 underscore the potential for radiation exposure from nuclear and radiological terrorism, which could result in large-scale casualties from improvised nuclear devices or nuclear weapons (2–4).

The acute radiation syndrome (ARS) occurs after whole-body exposure to radiation doses greater than 1 Gy. ARS is categorized into syndromes named for the organ system showing the most prominent symptoms. The central nervous system is affected within hours of exposures of more than 15 Gy, and fatalities occur within about 2 days. Gastrointestinal effects occur within a week after doses of 8 to 12 Gy, with only supportive care, most casualties will die within 10 days (4).

After doses of 1 to 7 Gy, the hematopoietic (also lymphatic and immunologic) system syndrome appears in weeks to 2 months. Survival is likely at the lower end of this range with administration of cytokines, antibiotics, and fluids and electrolytes (4).

Radiation causes injury of normal tissue by a dynamic, evolving process involving cell killing, altered cell-to-cell communication, and tissue repair. Compensatory tissue growth in normal tissue, and tissue repair, can be delayed (5, 6). Changes in cytokines can be delayed (6–8) and, indeed, radiation fi

To develop approaches to prophylaxis, mitigation, and treatment of radiation injuries, we need appropriate models to integrate the complex influences that occur in the radiation-exposed organism. This challenge was addressed in a recent workshop, “Models and Procedures for Evaluating Radioprotectors,” sponsored by the Radiation Research Program of the National Cancer Institute on 3 and 4 December 2003.

At present, no agents approved by the U.S. Food and Drug Administration are available for the treatment of ARS, although amifostine is approved for prophylaxis of dry mouth (xerostomia) from radiotherapy, and cytokines are used without approval for treatment of ARS. New research findings presented at the meeting, however, promise improvements in survival after whole-body radiation and reductions in the risk of adverse effects of radiotherapy.
• **X-rays:** High Dose Fluoroscopy
• **X-rays:** Multislice Spiral CT
• **γ-rays** Brachytherapy
• **RF:** Four MRI Zones
• **VL:** Laser Safety
• **US:** QC and Indices
LIE VERY QUIETLY AND TRY TO RELAX; EVERYONE IS A LITTLE NERVOUS WITH THEIR FIRST CAT SCAN.
USA TODAY

Election still splits court

Monday January 22, 2001

Bush debuts with education push

CT scans in children linked to cancer later
CT scans in children

By Steve Sternberg
USA TODAY

Each year, about 1.6 million children in the USA get CT scans to the head and abdomen — and about 1,500 of those will die later in life of radiation-induced cancer, according to research out today.

What’s more, CT or computed tomography scans given to kids are typically calibrated for adults, so children absorb two to six times the radiation needed to produce clear images, a second study shows. These doses are “way bigger than the sorts of doses that people at Three Mile Island were getting,”

David Brenner of Columbia says. “Most people got a tenths of the dose of a CT.”

Both studies appear in American Journal of Roentgenology’s leading radiology nation’s leading radiology.

first to establish radiation induced fatal cancer from CT scans. Until a decade ago, it too long to perform on child giving them anesthesia still. Today’s scanners spit patient in seconds, providing, or “slices,” of anatomy.

Doctors use CT scans
MY GOODNESS.... WHY, YOU'VE GROWN A FOOT SINCE I SAW YOU LAST.
ACR CT Accreditation Phantom
Gammex 464
• X-rays: High Dose Fluoroscopy
• X-rays: Multislice Spiral CT
• $\gamma$-rays Brachytherapy
• RF: Four MRI Zones
• VL: Laser Safety
• US: QC and Indices
• X-rays: High Dose Fluoroscopy
• X-rays: Multislice Spiral CT
• γ-rays Brachytherapy
• RF: Four MRI Zones
• VL: Laser Safety
• US: QC and Indices
• X-rays: High Dose Fluoroscopy
• X-rays: Multislice Spiral CT
• $\gamma$-rays Brachytherapy
• RF: Four MRI Zones
• VL: Laser Safety
• US: QC and Indices
Medical Lasers: Quality Control,
Safety Standards, and Regulations

Joint Report

Published for the American Association of Physicists in Medicine
and the American College of Medical Physics
by Medical Physics Publishing
RADIATION CONTROL AND QUALITY ASSURANCE: MEDICAL LASER SYSTEMS
A SUGGESTED PROTOCOL

A Report of the ACMP Task Group on
RADIATION CONTROL AND QUALITY ASSURANCE OF
MEDICAL LASER SYSTEMS
American National Standard for
Safe Use of Lasers
in Health Care Facilities
• X-rays: High Dose Fluoroscopy
• X-rays: Multislice Spiral CT
• γ-rays Brachytherapy
• RF: Four MRI Zones
• VL: Laser Safety
• US: QC and Indices
Protection in Nuclear Medicine and Ultrasound Diagnostic Procedures in Children
BIOLOGICAL EFFECTS OF ULTRASOUND: MECHANISMS AND CLINICAL IMPLICATIONS
Ultrasound Bioeffects

- Thermal
- Mechanical
Three Thermal Indices

• Soft Tissue Thermal Index
• Bone Thermal Index
• Fetal Thermal Index
RSO:
– medical physicist
– radiologist
– technologist
RSC:

- RSO
- QC technologist
- Radiologist
- Medical physicist
- Departments
RSC:
– Departments
  • Imaging
  • Nuclear medicine
  • Cardiology
  • Radiation oncology
  • Surgery
Regulations / Credentials / Signs
<table>
<thead>
<tr>
<th>MENU</th>
<th>RISKS</th>
<th>BENEFITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAMBURGERS</td>
<td>2.75</td>
<td>EAT A MEAL</td>
</tr>
<tr>
<td>CHEESEBURGERS</td>
<td>3.00</td>
<td>MAY NOT LOSE</td>
</tr>
<tr>
<td>HAM &amp; CHEESE</td>
<td>3.50</td>
<td>MIGHT GAIN</td>
</tr>
<tr>
<td>TUNA SURPRISE</td>
<td>1.95</td>
<td>MIGHT LOSSE</td>
</tr>
<tr>
<td>TURKEY</td>
<td>2.50</td>
<td>MIGHT EAT A</td>
</tr>
<tr>
<td>CHICKEN SALAD</td>
<td>3.00</td>
<td>MIGHT LOSE</td>
</tr>
<tr>
<td>REUBEN</td>
<td>3.50</td>
<td>MIGHT EAT A</td>
</tr>
<tr>
<td>PASTRAMI</td>
<td>3.75</td>
<td>MIGHT LOSE</td>
</tr>
</tbody>
</table>
THE LORDS PRAYER
- 71 WORDS
THE TEN COMMANDMENTS
- 168 WORDS
The Declaration of Independence was signed in Independence Hall, Philadelphia. The American artist John Trumbull painted this scene.
Abraham Lincoln Delivered the Gettysburg Address four months after the historic Civil War battle.

GETTYSBURG ADDRESS
Abraham Lincoln delivered the address to the site of the Battle of Gettysburg. He wrote five different versions of his famous Gettysburg Address. He held the second version, left below, in his hand while he spoke. The address is divided into two parts.

TWO VERSIONS OF THE GETTYSBURGH ADDRESS

THE GETTYSBURGH ADDRESS - 672 WORDS

Lincoln wrote five different versions of his famous Gettysburg Address. He held the second version, left below, in his hand while he spoke. The address is divided into two parts.

He wrote the first version, right above, in his hand while traveling. He revised in his changes to add in the Lincoln's notes. He took care that, ever since that day, it shall be considered as the deepest feelings of Americans.
Texas Regulations for Control of Radiation
Texas Regulations for Control of Radiation
679,432 words
Regulations / Credentials / Signs
Regulations / Credentials / Signs

- ABR
- ABMP
- ARRT
JCAHO 2002: Examples for MS.5.14

Granting of privileges for fluoroscopic x-ray equipment use

For physicians who use or operate fluoroscopic x-ray systems, the hospital delineates clinical privileges based on evidence of completion of specific training as conferred by appropriate board certification or completion of specific training courses. This training includes radiation safety, management of fluoroscopic radiation, and the operation of the specific fluoroscopic x-ray system(s) used. The physician must be proficient in the operation of the specific fluoroscopic x-ray system(s) used in the facility. Training in radiation safety and fluoroscopic radiation management is in addition to any clinical training or qualifications to perform the specific clinical diagnostic or therapeutic procedure(s) for which the fluoroscopic system is used.

The hospital requires specific documentation of appropriate training before granting fluoroscopic privileges, and evidence of appropriate training with respect to the operation of the specific fluoroscopic systems used in the facility before such use. In addition, the hospital provides annual in-service training or requires evidence of continuing medical education in radiation safety and management, for all physicians granted privileges to use fluoroscopic x-ray equipment.

FALLOUT SHELTER
21.901 Caution Signs

(a) Standard Radiation Symbol

Unless otherwise authorized by the Agency, the symbol prescribed by 21.901 shall use the colors magenta, or purple, or black on yellow background. The symbol prescribed is the three-bladed design as follows:

**RADIATION SYMBOL**

1. Cross-hatched area is to be magenta, or purple, or black, and
2. The background is to be yellow.
(c) Additional information on signs and labels. In addition to the contents of signs and labels prescribed in this part, the licensee may provide, on or near the required signs and labels, additional information, as appropriate, to make individuals aware of potential radiation exposures and to minimize the exposures.

§ 20.1902 Posting requirements.

(a) Posting of radiation areas. The

(b) Exception to Color Requirements for Standard Radiation Symbols

Notwithstanding the requirements of 21.901(a), licensees or registrants may label sources, source holders, or device components containing radionuclides that are subjected to high temperatures, with conspicuously etched radiation caution symbols and without a color requirement.

(c) Additional Information on Signs and Labels

In addition to the contents of signs and labels prescribed in this paragraph, the registrant shall provide, on or near the required signs and labels, any additional information, as appropriate, to make individuals aware of potential exposures and to minimize the exposures.
CAUTION

RADIATION AREA

Entering this room may result in a dose in excess of the allowed limit. Do not enter when the door is closed.
POSSIBLE RADIATION EXPOSURE

DO NOT OPEN WITHOUT PERMISSION
EMERGENCY INFORMATION

ROOM # 231

RESponsible FACULTY or STAFF PERSONS:

Bob Jackson
410.111

EMERGENCY NUMBER FOR FIRE, POLICE, AMBULANCE: 811

EMERGENCY PROCEDURE:
1. GIVE THE ALARM – pull fire alarm or alert others of an emergency
2. CALL 811 – give exact location of the emergency
3. CLOSE DOORS – and windows in the emergency area to confine or contain the emergency
4. EVACUATE – using the emergency stairwells ONLY.

DO NOT USE THE ELEVATORS!

SPECIAL HAZARDS IN THIS ROOM:

- CAUTION
- RADIOACTIVE MATERIALS
- BIOHAZARD
- CANCER HAZARD
- WEAR SAFETY GLASSES
- NO EATING OR DRINKING

PERSONS ENTERING THIS ROOM MAY BE EXPOSED TO RADIATION FROM RADIOACTIVE CHEMICALS
WARNING

DO NOT ENTER WHEN THE RED LIGHT IS ON

**********

DEADLY RADIATION LEVELS
WARNING

IF YOU ENTER THIS AREA WHILE THE RADIATION MACHINE IS ON
YOU MAY DIE!!!
DO NOT ENTER

IF YOU HAVE SLEPT WITH BILL CLINTON

BOOK IS CLOSED.
PREGNANT?
or think you might be...
tell your doctor before getting an x-ray or prescription
Caution

If there is any possibility that you are pregnant, it is very important that you inform the X-ray technologist before you have an X-ray.
LADIES: About to be X-rayed?
If you are PREGNANT or feel you might be pregnant, please tell the technologist so appropriate protective measures can be taken.

DAMAS: ¿Están ustedes dispuestas a radiografiarse?
Si está EMBARAZADA o cree que está embarazada por favor avísela al técnico para que el tome las medidas apropiadas para protegerla.

New Department of Radiography
ATTENTION

PLEASE INFORM THE TECHNOLOGIST IF YOU ARE PREGNANT
ATTENTION

PLEASE INFORM THE
MEDICAL PHYSICIST
IF YOU WISH
TO BECOME PREGNANT
WARNING

The Code of Practice requires that the door is kept closed during X-ray exposure.
NOTICE

NO NAKED LIGHTS OR SMOKING PERMITTED
THE ROYAL BOROUGH OF KENSINGTON & CHELSEA

ANY PERSON WHO PERMITS A DOG TO FOUL THE FOOTPATH IS LIABLE TO PROSECUTION UNDER THE COUNCIL’S BYE-LAW.
Beware of trains

Cycling Prohibited

Notice

All persons are warned not to trespass upon the railways or stations of the company. Any person who trespasses upon any such railway or station in such manner as to expose himself to danger in the performance of their duties renders himself liable to a penalty of forty shillings and is in default of payment liable to one month's imprisonment for every such offence.

By order.
Box Crossing

Do not enter box unless your exit is clear

Beware of trains
Stop look and listen before crossing the line
Danger
Do not touch the live rail
Warning
Do not trespass on the Railway
Penalty £25
Positively no smoking or open flames allowed

Don't even think of parking here! Tow away zone
NOTICE
DO NOT LEAVE GROUNDS WITHOUT YOUR CAR
We Care for You
BAYLOR COLLEGE OF MEDICINE IS SMOKE-FREE

NO GUNS
NO ARMAS
Extraordinary situations:

- Terrorism (dirty bomb)
- Nuclear accident (waste, reactor)
- Industrial accident (source exposure)
PUBLIC HEALTH STRATEGIES FOR PROTECTING THE THYROID WITH POTASSIUM IODIDE IN THE EVENT OF A NUCLEAR INCIDENT
A symposium of the American Thyroid Association

FRIDAY, FEBRUARY 28, 2003
Hyatt Regency Washington on Capitol Hill
Washington, DC

Supported by the American Thyroid Association (ATA) and the American Association of Clinical Endocrinologists (AACE)

Continuing Medical Education Sponsored by The Johns Hopkins University School of Medicine in conjunction with the ATA
MANAGEMENT OF TERRORIST EVENTS INVOLVING RADIOACTIVE MATERIAL

National Council on Radiation Protection and Measurements
\[ \Delta x \Delta p \approx \hbar \alpha_0 \Delta E \Delta c = \int \left( \frac{\hbar^2}{m c} \right) \left( \frac{k_e^2}{\hbar c} \right) dx = \frac{M \varepsilon}{\hbar} \]
Conclusions:

- Proactive RSC
- Minutes (electronic)
- Avoid Litigation
- Regulations proof