PATIENT RADIATION DOSES IN DIAGNOSTIC RADIOLOGY

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ORGANIZATION OF THE PRESENTATIONS

• PART 1: INTRODUCTION & REVIEW
  – REVIEW OF DIFFERENT UNITS OF RADIATION MEASUREMENTS
  – FACTORS THAT INFLUENCE PATIENT RADIATION DOSE
  – PRACTICAL METHODS FOR ESTIMATING PATIENT RADIATION DOSES
  – WITH REFERENCES
ORGANIZATION OF THE PRESENTATIONS

• PART 2: TYPICAL RADIATION DOSE VALUES, RISKS & DEALING WITH PUBLIC
  – N.E.X.T. SURVEYS
  – REFERENCE VALUES
  – FETAL DOSE CALCULATION GUIDES
  – REVIEW OF SOME BIOLOGICAL RISKS
  – DEALING WITH THE PUBLIC
- WITH REFERENCES

PATIENT RADIATION DOSES IN DIAGNOSTIC RADIOLOGY… part 1

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Radiation Quantity and Unit

- **EXPOSURE (X):**
  Amount of ion pairs created in air by x-ray or gamma radiation. Unit is Roentgen.
- $1 \text{ R} = 2.58 \times 10^{-4} \text{(C/kg)}$
Radiation Quantity and Unit

- **ABSORBED DOSE (D):** Energy absorbed from ionizing radiation per unit mass.
- SI Unit is J/kg or Gray (Gy).
- Conventional unit is rad.
  
  \[ 1 \text{ Gy} = 100 \text{ rad} \text{ or } 1 \text{ rad} = 10 \text{ mGy} \]
- Soft tissue f-factor: 0.93 for diagnostic.

Radiation Quantity and Unit

- **Equivalent Dose (H):** Converts absorbed dose to equivalent tissue damage for different types of radiation.
- ICRP 92: radiation-weighted dose
- For X-ray, the weighting factor \( W_R \) is 1.
- SI unit is Sievert (Sv).
- Conventional unit is rem.
  
  \[ 1 \text{ Sv} = 100 \text{ rem} \text{ or } 1 \text{ rem} = 10 \text{ mSv} \]
Radiation Quantity and Unit

- **Effective Dose (E):**
  - Concerns different tissue radiosensitivity
  - Tissue weighting factors were established
  - Assigned the proportion of the risk of stochastic effects (Includes fatal + non-fatal cancer risks + serious hereditary effects to all generations) resulting from irradiation of that tissue compared to a uniform whole body irradiation.
  - Weighting individual tissue dose to derive the whole body equivalent.

\[
E = \sum_{T} W_T W_R D_T
\]

Evolving Tissue-Weighting Factors

<table>
<thead>
<tr>
<th>Tissue Type</th>
<th>ICRP 26 (1977)</th>
<th>ICRP 60 (1991)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonads</td>
<td>0.25</td>
<td>0.20</td>
</tr>
<tr>
<td>Red Bone Marrow</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>Colon</td>
<td></td>
<td>0.12</td>
</tr>
<tr>
<td>Lungs</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>Stomach</td>
<td></td>
<td>0.12</td>
</tr>
<tr>
<td>Bladder</td>
<td></td>
<td>0.05</td>
</tr>
<tr>
<td>Breast</td>
<td>0.15</td>
<td>0.05</td>
</tr>
<tr>
<td>Liver</td>
<td></td>
<td>0.05</td>
</tr>
<tr>
<td>Esophagus</td>
<td></td>
<td>0.05</td>
</tr>
<tr>
<td>Thyroid</td>
<td>0.03</td>
<td>0.05</td>
</tr>
<tr>
<td>Skin</td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td>Bone Surface</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>Remainder</td>
<td>0.30</td>
<td>0.05</td>
</tr>
<tr>
<td>Total</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>
### OUTLINE

**Part I**

2. FACTORS THAT INFLUENCE PATIENT RADIATION DOSE

- Radiography
- Fluoroscopy
- Mammography
- Computed Tomography
Dose Affecting Factors

- **X-RAY BEAM ENERGY (KVP):** higher kVp results in lower dose.
- **ADDED FILTRATION:** Higher added filtration results in lower dose.
- **COLLIMATION:** Aggressive collimation reduces the irradiated area as well as scatter radiation.
- **GRIDS:** Grids reduce scatter radiation but increase patient dose.

More Dose Affecting Factors

- **IMAGE RECEPTOR:** Faster speed image receptor reduces patient dose.
- **TUBE CURRENT AND EXPOSURE TIME (mAs):** The patient dose is proportional to mAs.
- **PATIENT SIZE:** It is beneficial to optimize the technique chart for various patient size and anatomic areas.
CR:

- CR plates have lower speed, typically speed 200;
- Data manipulation tools available for digital image processing;
- More added filtration and higher kVp may be used to reduce patient dose.

DR:

- Usually, DR speed is faster.
- DR speed can be programmed according to the acceptable image noise level.

Dose Affecting Factors in Mammography

- Target materials: Molybdenum/Rhodium.
- Filter materials: filter target combination.
- Grids: The Bucky factor for mammography grids is usually in the range of 2-3.
- Mag mode: magnification increases dose.
- Compression
- Breast size and tissue composition
- kVp is 24-30 kVp. RBE for such low energy x-ray photons is higher (BJR 79(2006):195-200).
Dose Affecting Factors in Fluoroscopy

- Pulsed fluoroscopy vs. continuous fluoroscopy;
- Modern fluoroscopy systems are entirely automated.
- Various programmable features are available.

ESER Reduction With Added Filtration
22 cm FOV, continuous fluoroscopy

Acrylic Phantom Thickness (cm)
ESER (R/min)

- 0.0mm Cu
- 0.1mm Cu
- 0.2mm Cu
- 0.3mm Cu

ADULT DIAGNOSTIC CORONARY ANGIOGRAPHY
(BASELINE: 16cm FoV, C PLUS, 30pps, GRID, 25cm PMMA)

SELECTABLE VARIABLES

PERCENT RADIATION DOSE (%)
Factors Affecting CTDI

• X-RAY BEAM ENERGY (KVP): higher kVp results in higher CTDI values.
• X-RAY TUBE CURRENT (mA): dose is proportional to mAs.
• TUBE ROTATION TIME: dose is proportional to mAs.
• PITCH: inversely proportional to dose.
• X-RAY BEAM COLLIMATION: thinner collimation results in higher CTDI values.

Factors Affecting CTDI (…continued)

• PATIENT SIZE: smaller patient size results in higher CTDI values.
• DOSE REDUCTION TECHNIQUE, i.e., mA modulation technique
• DETECTOR CONFIGURATION
• SLICE THICKNESS
• ADDED FILTRATION
• GEOMETRIC EFFICIENCY
Take a guess

If the body size is reduced from 32 cm in diameter to 16 cm in diameter, the CTDI will be __________.

- A. the same
- B. increased by 50%
- C. doubled
- D. more than doubled

Body Scan

Nickoloff, et al, AAPM Annual Meeting, Seattle, WA, 2005
COMPARISON OF BODY CT RADIATION DOSE PER 100 mAs vs. WEIGHT

RADIATION DOSE (mGy / 100 mAs)

PATIENT WEIGHT (lbs.)

- CTvol / 100 mAs
- MEAS. / 100 mAs
OUTLINE
Part I

3. PRACTICAL METHODS FOR ESTIMATING PATIENT RADIATION DOSES WITH REFERENCES

Phantoms

- Acrylic phantoms
- Anthropomorphic phantoms:
- Mathematical phantoms:
  - Reference Man
Limitations of Tabular Conversion Factors

- The reference person (male 154lb, female 128lb) has a fixed size.
- The number of exam types is limited.
- The number of exam settings is limited: field size, SID, etc.
- The number of organ types is limited.
- The data were based upon cancer detriment index published earlier (need updated).
Organ Dose Estimation from ESE for Radiography

- This handbook contains data from which absorbed dose to selected tissues can be estimated.
- Monte Carlo simulation.
- Using reference male/female.
- Specific to exam and equipment; for selected common projections only.

Free download at http://www.fda.gov/cdrh/ohip/organdose.html

Example: AP Chest Steps for Tissue Dose Estimation

- Measure exposure mR/mAs and HVL on the machine;
- Figure out the techniques (kVp and mAs) for the particular image;
- Calculate patient entrance skin exposure (ESE).
- Look up in the handbook for corresponding conversion factors.
<table>
<thead>
<tr>
<th>Tissue Doses (Rads) and Cals</th>
<th>Lungs</th>
<th>Active Bone Marrow</th>
<th>Thyroid</th>
<th>Skin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>3.5</td>
<td>2.5</td>
<td>3.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Female</td>
<td>3.5</td>
<td>2.5</td>
<td>3.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Example: AP Chest
## ACR CT ACCREDITATION FORM

### Section 11 - Radiation Dosimetry (Adult Body)

Use the TAB key to move between data entry cells in the column named *Measured*

<table>
<thead>
<tr>
<th>CTDI Body Phantom (32-cm diameter PMMA Phantom)</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>kVp</td>
<td>120</td>
</tr>
<tr>
<td>mA</td>
<td><strong>480</strong></td>
</tr>
<tr>
<td>Exposure time per rotation (s)</td>
<td>0.5</td>
</tr>
<tr>
<td>Z axis collimation T (mm)</td>
<td>3</td>
</tr>
<tr>
<td># data channels <em>used</em> (N)</td>
<td><strong>6</strong></td>
</tr>
<tr>
<td>Axial (A): Table Increment (mm) = (I)</td>
<td>24</td>
</tr>
<tr>
<td>OR Helical (H): Table Speed (mm/rot) = (I)</td>
<td>100</td>
</tr>
<tr>
<td>Active Chamber length (mm)</td>
<td><strong>1.98</strong></td>
</tr>
<tr>
<td>Chamber correction factor</td>
<td></td>
</tr>
</tbody>
</table>
CTDI$_{vol}$ and DLP

\[ CTDI_{vol} = \frac{1}{\text{pitch}} CTDI_w \]

where pitch is the ratio of table increment per tube rotation divided by total x-ray beam width of all collimations.

\[ DLP = CTDI_{vol} \times \text{scan length} \]

Effective Dose in CT

- European Guidelines on Quality Criteria for CT
  (http://www.drs.dk/guidelines/ct/quality/index.htm)

<table>
<thead>
<tr>
<th>Region of body</th>
<th>Normalized Effective Dose (mSv/mGy-cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>0.0023</td>
</tr>
<tr>
<td>Neck</td>
<td>0.0054</td>
</tr>
<tr>
<td>Chest</td>
<td>0.017</td>
</tr>
<tr>
<td>Abdomen</td>
<td>0.015</td>
</tr>
<tr>
<td>Pelvis</td>
<td>0.019</td>
</tr>
</tbody>
</table>
Software Resources

Software programs to calculate organ dose using Monte Carlo Techniques:

- [www.hpa.org.uk](http://www.hpa.org.uk) (NRPB):
  XDOSE, CHILDOSE, CTDOSE
- [www.vamp-gmbh.de](http://www.vamp-gmbh.de) (company for CT):
  ImpactDose

PATIENT RADIATION DOSES IN DIAGNOSTIC RADIOLOGY… part 2

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### TYPICAL PATIENT RADIATION DOSES

#### GI SPOT (1)

<table>
<thead>
<tr>
<th>EXAMINATION &amp; PROJECTION</th>
<th>1st QUARTILE (mGy)</th>
<th>MEDIAN (mGy)</th>
<th>3rd QUARTILE (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEST PA</td>
<td>0.08</td>
<td>0.11</td>
<td>0.46</td>
</tr>
<tr>
<td>ABDOMEN AP</td>
<td>1.7</td>
<td>2.4</td>
<td>3.4</td>
</tr>
<tr>
<td>LS SPINE AP</td>
<td>2.0</td>
<td>2.8</td>
<td>4.2</td>
</tr>
<tr>
<td>GI FLUORO / min</td>
<td>3.39</td>
<td>48.7</td>
<td>69.8</td>
</tr>
<tr>
<td>GI SPOT (1)</td>
<td>2.21</td>
<td>3.30</td>
<td>4.83</td>
</tr>
<tr>
<td>CTDvol HEAD</td>
<td>43</td>
<td>58</td>
<td>75</td>
</tr>
<tr>
<td>CTDvol BODY</td>
<td>11</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>MAMMO</td>
<td>1.0</td>
<td>1.4</td>
<td>1.9</td>
</tr>
</tbody>
</table>

* FROM: [WWW.CRCPD.ORG](http://WWW.CRCPD.ORG) WEBSITE & ACR MAMMO
DIAGNOSTIC RADIOLOGY DOSE REFERENCE LEVELS (DRL)

DIAGNOSTIC REFERENCE LEVELS

- VOLUNTARY FOR COMPARISON
  - BASED UPON NATIONWIDE SURVEYS
  - NOT FOR REGULATORY PURPOSES
- GUIDANCE LEVEL FOR INVESTIGATION... IF ABOVE
  - MAY BE APPROPRIATE BECAUSE OF PATIENT SIZE OR CLINICAL COMPLEXITY
  - MAY BE SUBOPTIMAL USAGE OF EQUIPMENT
  - MAY BE EQUIPMENT PROBLEMS
- TYPICALLY REFERENCE LEVEL IS THIRD QUARTILE OR ABOUT 80% OF SURVEY
  - MEAN + 0.70 σ → 75 %
  - MEAN + 1.00 σ → 84 %
- DIRECTED TOWARDS RADIATION DOSE REDUCTION
# ACR / AAPM Reference Values for Adults

<table>
<thead>
<tr>
<th>EXAMINATION &amp; PROJECTION</th>
<th>REFERENCE VALUE (mGy / IMAGE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEST PA</td>
<td>0.25</td>
</tr>
<tr>
<td>ABDOMEN AP</td>
<td>4.50</td>
</tr>
<tr>
<td>LS SPINE AP</td>
<td>5.00</td>
</tr>
<tr>
<td>CERVICAL SPINE AP</td>
<td>1.25</td>
</tr>
<tr>
<td>GI FLUORO / min</td>
<td>65.0</td>
</tr>
<tr>
<td>CTDic HEAD</td>
<td>60.0</td>
</tr>
<tr>
<td>CTDlp BODY</td>
<td>40.0</td>
</tr>
<tr>
<td>MAMMO</td>
<td>3.00 (MQSA)</td>
</tr>
</tbody>
</table>

# ACRIN Mammography Data

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SCREEN-FILM</th>
<th>FFDM</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEAN THICK.</td>
<td>5.29 cm</td>
<td>5.28 cm</td>
</tr>
<tr>
<td>1 σ THICK.</td>
<td>1.37 cm</td>
<td>1.45 cm</td>
</tr>
<tr>
<td>MEAN DOSE</td>
<td>2.37 mGy</td>
<td>1.88 mGy</td>
</tr>
<tr>
<td>1 σ DOSE</td>
<td>0.99 mGy</td>
<td>0.68 mGy</td>
</tr>
<tr>
<td>MEAN + 1σ DOSE</td>
<td>3.36 mGy</td>
<td>2.56 mGy</td>
</tr>
</tbody>
</table>

From Drs. Eric Berns & Ed Hendrick at Northwestern Univ.
### UK Diagnostic Reference Levels 2000

<table>
<thead>
<tr>
<th>EXAMINATION &amp; PROJECTION</th>
<th>DRL (mGy/image)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SKULL AP/PA</td>
<td>3.0</td>
</tr>
<tr>
<td>SKULL LAT</td>
<td>1.5</td>
</tr>
<tr>
<td>CHEST PA</td>
<td>0.2</td>
</tr>
<tr>
<td>CHEST LAT</td>
<td>1.0</td>
</tr>
<tr>
<td>THOR. SPINE AP</td>
<td>3.5</td>
</tr>
<tr>
<td>THOR. SPINE LAT</td>
<td>16</td>
</tr>
<tr>
<td>LS SPINE AP</td>
<td>6.0</td>
</tr>
<tr>
<td>LS SPINE LAT</td>
<td>14.0</td>
</tr>
</tbody>
</table>

**WEBSITE:** www.hpa.org.uk/radiation

### UK Diagnostic Reference Levels 2000

<table>
<thead>
<tr>
<th>EXAMINATION &amp; PROJECTION</th>
<th>DRL as DAP (Gy-cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABDOMEN AP</td>
<td>3.0 (6 mGy/image)</td>
</tr>
<tr>
<td>PELVIS AP</td>
<td>3.0 (4 mGy/image)</td>
</tr>
<tr>
<td>BARIUM SWALLOW*</td>
<td>11</td>
</tr>
<tr>
<td>BARIUM MEAL*</td>
<td>13</td>
</tr>
<tr>
<td>BARIUM ENEMA*</td>
<td>31</td>
</tr>
<tr>
<td>RETRO. PYLEO.*</td>
<td>13</td>
</tr>
<tr>
<td>Dx CORONARY ANGIOGRAPHY*</td>
<td>36</td>
</tr>
</tbody>
</table>

* FOR ENTIRE PROCEDURE
### OTHER EUROPEAN DRL

<table>
<thead>
<tr>
<th>EXAMIN. &amp; PROJ.</th>
<th>IRELAND (mGy/im.)</th>
<th>CEC (mGy/im.)</th>
<th>SWITZERLAND (mGy/im.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEST PA</td>
<td>0.3</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>ABDOMEN AP</td>
<td>6.0</td>
<td>10.0</td>
<td>7.0</td>
</tr>
<tr>
<td>PELVIS AP</td>
<td>7.0</td>
<td>10.0</td>
<td>7.8</td>
</tr>
<tr>
<td>LS SPINE AP</td>
<td>8.0</td>
<td>10.0</td>
<td>8.7</td>
</tr>
<tr>
<td>LS SPINE LAT</td>
<td>24.0</td>
<td>30.0</td>
<td>26.0</td>
</tr>
</tbody>
</table>

### DRL FOR PEDIATRIC PATIENTS

<table>
<thead>
<tr>
<th>EXAMINATION &amp; PROJECTION</th>
<th>DRL [ FOR 5 YRS. OLD ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>SKULL AP</td>
<td>1.25 mGy/image</td>
</tr>
<tr>
<td>CHEST PA/AP</td>
<td>0.11 mGy/image</td>
</tr>
<tr>
<td>ABDOMEN AP</td>
<td>0.58 mGy/image</td>
</tr>
<tr>
<td>PELVIS AP</td>
<td>0.51 mGy/image</td>
</tr>
<tr>
<td>BARIUM MEAL</td>
<td>2.0 Gy-cm²</td>
</tr>
</tbody>
</table>
PEDIATRIC PATIENT DOSES

• NEED TO SCALE FOR AGE AND SIZE
  – WEIGHT CORRELATES BEST
• TO SCALE RADIATION DOSE WITH AGE, A ROUGH APPROXIMATION:
  – AGE 5 YRS → 1 YRS USE 0.5 - 0.6 x’s
  – AGE 5 YRS → 10 YRS USE 1.5 - 2.0 x’s
  – AGE 10 YRS → 15 YRS. USE 1.5 - 2.0 x’s
  – AGE 15 YRS → ADULT USE 1.5 - 2.0 x’s
• SCALING FOR HEAD IMAGING LESS

FETAL DOSE ESTIMATIONS
ESTIMATION OF FETAL RADIATION DOSES

• FROM FDA 92-8031 “HANDBOOK OF SELECTED TISSUE DOSE FOR.....”
• DEPENDS UPON: kVp, HVL, PROJ., WAVEFORM, PAT. SIZE, FoV, etc.
• MULTIPLY ESD (w/o BACK SCATTER) ..... FETUS IN DIRECT BEAM BY:
  – FOR AP VIEW, USE 0.35 – 0.50 or “4 / 10”
  – FOR PA VIEW, USE 0.17 – 0.35 or “1 / 4”
  – FOR LAT VIEW, USE 0.5 – 0.13 or “1/ 10”

ESTIMATION OF FETAL RADIATION DOSES

• ESD OUTSIDE OF THE DIRECT X-RAY BEAM:
  – AT EDGE OF COLLIMATION, ESD IS 20-30% OF DIRECT BEAM ESD
  – EACH 4 cm OUTSIDE OF DIRECT BEAM REDUCES ESD BY 40-60% OF DIRECT BEAM ESD (except in lungs)
  – BEYOND 16 cm ESD < 1% OF DIRECT BEAM .... IGNORE DOSE (most cases)
  – CORRECT FOR DEPTH ≈ (4/10) FOR AP
• DEPENDS UPON STAGE OF PREGNANCY
RADIATION BIO-RISKS

SKIN ERYTHEMIA

- EARLY TRANSIENT ERYTHEMA .... 2 Gy
- SIGNIFICANT ERYTHEMIA .... 6 Gy
- DRY DESQUAMATION .... 10 Gy
- MOIST DESQUAMATION .... 15 Gy
- LATE ERYTHEMA & NECROSIS .... 15 - 20 Gy
- TEMPORARY EPIILATION .... 3 – 6 Gy
- PERMANENT EPIILATION .... > 7 Gy
- CONCERN: INTERVENTIONIAL ANGIOGRAPHY & CARDIAC STUDIES

PARRY RA, GLAZE SA & ARCHER BR...RADIOGRAPHICS 19(5):1289-302
PROBABILITY OF CATARACT INDUCTION

EYE LENS DOSE (cGy)

LATENT PERIOD
3 -17 YRS ... AVER 7 YRS

EXCESS CANCER MORTALITY BY AGE AT EXPOSURE
[ NON-LEUKEMIA MORTALITIES FROM BEIR V REPORT]
RADIATION INDUCED CANCER RISKS

- **FATAL CANCER** = 15.3% / Sv FOR FEMALE AND 12.8% / Sv MALES AT 5 YRS AGE... BEIR V
- **FATAL CANCERS** = 13.5% / Sv FOR FEMALES AND 8.5% / Sv MALES AT 5 YRS... BEIR VII
- **FATAL CANCERS** = 5.7% / Sv AT 40 - 45 YRS AGE ... BEIR V & 4.3% / Sv .... BEIR VII
- **FATAL CANCERS** = 2.8% / Sv AT 70 YRS AGE
- **TYPICAL [4.3% FATAL + 2.9% NON-FATAL] / Sv**
- **EXPRESSION PERIOD IS LONG**
  - 0 - 15 YRS FOR LEUKEMIA
  - 10 - > 30 YRS FOR SOLID TUMORS
- **SPREAD SAME DOSE ANNUALLY THROUGH LIFETIME PRODUCES FATAL CANCERS ≈ 4.9% / Sv**

* SINGLE DOSE OF 1.0 Sv ... LINEARLY SCALED

FETAL RADIATION DOSE RISKS

- **FIRST 8-10 DAYS.... PRE-IMPLANTATION PERIOD: 0 – 3% / cGy FATAL/ABORT**
- **FIRST TRIMESTER... 2 – 15 WEEKS**
  - MICROCEPHALY ≤ 0.5 – 1% / cGy
  - SEVERE RETARDATION ≤ 0.4% / cGy WITH THRESHOLD > 20 – 40 cGy
  - I.Q. DEFICIT .... THRESHOLD > 10 cGy
  - SEVERE MALFORMATION > 50 – 100 cGy
- **2ND & 3RD TRIMESTERS... > 15 – 24 WEEKS**
  - INCREASED RISK OF LEUKEMIA ... 3 x’s ADULT
  - INCREASED RISK OF CANCER ... 4 - 5 x’s ADULT
  - CANCER RISK ≤ 0.25 - 0.48 % / cGy

Wagner LK et al., *Exposure of the Pregnant Patient to Dx Radiations and BEIR V & BEIR VII reports*
SEVERE RADIATION INDUCED GENETIC RISKS

- **AUTOSOMAL DOMINANT & X-LINKED**
  - 0.075 – 0.2% / Sv ..... BEIR V
- **CHRONIC**
  - 0.025 – 0.12 % / Sv ..... HP 80(4):363
- **CONGENTIAL**
  - 0.1 - 0.2 % / Sv ..... HP & BEIR V
- **TOTAL GENETIC EFFECTS**
  - 0.3 – 0.47 % / Sv .... Health Phys 80(4):363
  - 1.3 % / Sv ..... NCRP No. 116
  - 1.7% to 2.8% / Sv .... BEIR V & BEIR VII
  - **DOUBLING DOSE IS ABOUT 0.80 – 1.0 Sv**

EXAMPLES OF GENETIC MUTATION DISEASES

- **AUTOSOMAL DOMINANT**
  - Retinoblastoma, intestinal polyposis, Marfan syndrome, polycystic kidneys, Huntington’s
- **X-LINKED RECESSIVES**
  - Hemophilia, Incontinentia, pigmenti, Orofaciodigital syndrome
- **CHRONIC DISEASE**
  - Grave’s, diabetes mellitus, asthma, coeliac, psoriasis, scoliosis
- **CONGENITAL ABNORMALITIES**
  - Spina bifida, cleft lip, dislocation of hip, inguinal hernia, ventricular septal defects, heart disease, stroke
RADIATION DOSE & CNS FUNCTION

• A RELATIVELY UNEXPLORED AREA
  – VISUAL MOTOR CO-ORDINATION
  – COGNITION FUNCTIONS
  – INTELLIGENCE QUOTIENT (I.Q.)
  – ATTENTION DEFICIT
  – SOCIAL SKILLS
  – SUCCESS IN SCHOOL
• PUBLICATIONS REGARDING:
  – RADIATION THERAPY OF HEAD
  – VARIOUS TREATMENTS TO SINUS etc
  – FETAL IRRADIATIONS
  – ATOM BOMB DATA DOES NOT CORRELATE

RADIATION DOSE & CNS FUNCTIONS

• STUDY OF 3094 SWEDISH MEN WHO RECEIVED HEAD RADIATION BEFORE 18 MONTHS (AVERAGE FRONTAL BRAIN DOSE 100 mGy): [BJM 2004...Per Hall]
  – DECREASED H.S. ATTENDANCE
  – LOWER COGNITIVE TEST SCORES
  – DECREASED LOGICAL REASONING & LEARNING ABILITIES
• BEIR V REPORT FOR FETAL DOSES:
  – 43% SEVERE MENTAL RETARDATION AT 1 Gy
  – INTELLIGENCE SCORES DOWN 21-29 POINTS/ 1 Gy
  – THRESHOLD FOR RETARDATION 0.2 - 0.4 Gy
  – MOST SENSITIVE PERIOD 8-15 WEEKS POST CONCEPTION (7 – 24 WEEKS TOTAL)
DEALING WITH THE PUBLIC

OBSTACLES IN COMMUNICATING WITH PUBLIC ABOUT RADIAITON

• AMERICANS BELIEVE GOV’T HAS LIED TO THEM
• PUBLIC BELIEVES RADIATION IS INVISIBLE AND UNDETECTABLE (TRUTH: CAN DETECT DOWN TO BACKGROUND LEVELS)
• AVERAGE PERSON HAS LIMITED SCIENTIFIC KNOWLEDGE OF UNIVERSE
• THERE IS A GENERAL FEAR ABOUT CANCER, BIRTH DEFECTS AND RADIATION
• PUBLIC DOES NOT KNOW “JARGON” OR MATHEMATICS OF SCIENTISTS
• PUBLIC NOT COGNITIVE OF DAILY EXPOSURE TO RADIATION AND OTHER LIFE HAZARDS & RISKS
HINTS FOR DEALING WITH THE PUBLIC

• OBTAIN INSTITUTIONAL APPROVALS FOR ANY RELEASES OF INFORMATION
• PROVIDE AN BRIEF INTRODUCTION TO YOURSELF
  – TITLE & POSITION IN ORGANIZATION
  – COLLEGE DEGREES & MAJOR
  – EXPERIENCE
  – BOARD CERTIFICATION / LICENSES
• IDENTIFY “WHAT INFORMATION” YOU WILL PROVIDE & DISCUSS
• HAVE DOCUMENTATION:
  – WRITTEN
  – VIDEO / AUDIO
  – WITNESS TO THE PRESENTATION

HINTS FOR DEALING WITH THE PUBLIC

• SPEAK OR WRITE IN NON-TECHNICAL TERMS .... KEEP IT SIMPLE
• DO NOT MISREPRESENT THE SITUATION or COVER-UP FACTS
• DO NOT MINIMIZE PUBLIC CONCERNS – BE SYMPATHETIC & LISTEN
• PROVIDE REFERENCE MATERIAL
  – WEB SITES
  – LITERATURE
  – CONTACT ORGANIZATIONS
HINTS FOR DEALING WITH THE PUBLIC

- **DO NOT** ANSWER QUESTIONS THAT YOU ARE NOT QUALIFIED TO DISCUSS
  - LEGAL
  - MEDICAL
  - ADMINISTRATIVE
- **DO NOT** SPECULATE ABOUT ISSUES
- **DO NOT** INTERJECT PERSONAL OPINIONS
- **RELATE** RADIATION DOSES TO PRACTICAL VALUES
  - COMMON COMPARABLE RADIATION LEVELS
  - RELATE RADIATION RISKS TO OTHER RISKS

RELATING RADIATION LEVELS & RISKS

- **BACKGROUND EQUIVALENT RADIATION TIME** (BERT) .... Dr. J Cameron, HP Newsletter
  - 1 mSv / YR WITHOUT WITHOUT RADON
  - 3 mSv / YR WITH RADON
- **CROSS HAZARD COMPARISON** ... AB Brill, SNM .... FATAL RISKS = 1 case in 1 million
  - 1 P/A CHEST X-RAY
  - DRIVING 30 MILES BY CAR
  - FLYING 1,000-2,500 MILES BY JET AIRPLANE*
  - DRINKING 0.5 LITER OF WINE
  - SMOKING 1 - 10 CIGARETTES*
  - 40 TABLESPOONS OF PEANUT BUTTER
  - 1 HOUR OF LIFE AT 74 YRS OLD
  - * modified for reference
<table>
<thead>
<tr>
<th>X-RAY EXAM</th>
<th>EFF.DOSE (mSv)</th>
<th>ABS. CANCER RISKS</th>
<th>EQUIV. CIGARET.</th>
<th>CAR TRAVEL MILES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 CHEST P/A</td>
<td>.032 (0.075)</td>
<td>1.3 x 10^-6</td>
<td>9 (31)</td>
<td>23 (80)</td>
</tr>
<tr>
<td>HEAD CT</td>
<td>2.0</td>
<td>1.2 x 10^-4</td>
<td>830</td>
<td>2,120</td>
</tr>
<tr>
<td>BARIUM ENEMA</td>
<td>0.54 (20)</td>
<td>2 x 10^-5</td>
<td>148 (8,310)</td>
<td>357 (21,230)</td>
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<tr>
<td>BONE SCAN</td>
<td>4.40</td>
<td>1.8 x 10^-4</td>
<td>1,300</td>
<td>3,200</td>
</tr>
</tbody>
</table>

www.umich.edu/~radinfo/introduction/risks.htm AND

### RELATIVE RISKS OF DEATH IN ONE YEAR

<table>
<thead>
<tr>
<th>TERM</th>
<th>RISK RANGE</th>
<th>EXAMPLE</th>
<th>RISK ESTIMATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH</td>
<td>&gt; 1:100</td>
<td>Space Shuttle Crew Fatal</td>
<td>1 : 100</td>
</tr>
<tr>
<td>MODERATE</td>
<td>1:100 to 1:1,000</td>
<td>Smoking 10 cigarette / day</td>
<td>1:200</td>
</tr>
<tr>
<td>LOW</td>
<td>1:1,000 to 1:10,000</td>
<td>Accident on the road</td>
<td>1:8,000</td>
</tr>
<tr>
<td>VERY LOW</td>
<td>1:10,000 to 1:100,000</td>
<td>Accident at home</td>
<td>1:26,000</td>
</tr>
<tr>
<td>MINIMAL</td>
<td>1:100,000 to 1:1,000,000</td>
<td>Homocide</td>
<td>1:100,000</td>
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<tr>
<td>NEGLIGIBLE</td>
<td>&lt;1:1,000,000</td>
<td>Hit by lightning</td>
<td>1:10M</td>
</tr>
</tbody>
</table>

J. Lakey, Health Physics 75(4):367-374; 1998
HINTS FOR DEALING WITH THE PUBLIC

• BE COURTEOUS ... NOT CURT
• DO NOT BE CONDESCENDING IN YOUR ATTITUDE
• DO NOT GET "SIDE TRACKED" ON OTHER ISSUES
• ASK IF THERE IS ANYTHING ELSE YOU CAN DO TO ANSWER THEIR CONCERNS
• THANK EVERYONE FOR THEIR ATTENTION
• EXCUSE YOURSELF

THANK YOU FOR YOUR ATTENTION .... TIME FOR DISCUSSIONS

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