## Optimization of Radiation Dose and Image Quality in Diagnostic Radiology— Digital and Screen-Film Imaging

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## Question of the Day…

Do you know what your doses are?

## NEXT Survey Results

(mR or R/min)

| *Exam* | *Min* | *Max* | *Max/Min* |
|---|---|---|---|
| PA Chest | 2.4 | 81 | 33.8 |
| AP L. Spine | 62 | 2,154 | 34.7 |
| GI Exams | | | |
| Rate | 0.7 | 16.2 | 23.1 |
| Spot Film | 38 | 4,815 | 126.7 |
| CT Head | 1,600 | 14,000 | 8.8 |

## Reference Values (mrad)

| | |
|---|---|
| PA Chest | 25 |
| Cervical Spine | 125 |
| AP Abdomen and AP Lumbar Spine | 500 |
| CT Head | 6,000 |
| CT Body | 4,000 |
| Fluoroscopic Rate (per min) | 6,500 |
| Dental Bitewings | 275 |
| Cephalometry | 25 |

## Is Dose the Only Concern?

*NO!!!*

High doses usually mean poor image quality!

Low doses sometimes mean poor image quality!

## High Population Dose?

| *Exam* | *% Exams* | *% CED* |
|---|---|---|
| Chest | 39.3 | 0.7 |
| CT Body | 5.0 | 35 |
| Angio* | 1.2 | 22 |
| GI | 5.0 | 19 |
| *Total* | *11.2* | *76* |

*Cardiac, Neuro, Vascular

## Potential for Unlimited Exposure

- High Level Control (HLC)
- Fluoroscopic Procedures
- Any and All Digital Modalities
  - Computed Tomography
  - Computed Radiography
  - Digital Radiography

## *Tackle Three Major Contributors First!!!*

Angiography
GI Examinations
Computed Tomography

## Angiography, Fluoroscopy, and Radiography Dose Reduction

General Principles

- Increase HVL from 2.3 mm to >3.2 mm Al at 80 kVp
  - Reduces exposure about 35% and dose about 25%
  - No increase in tube loading
  - No change in film density
  - No loss of contrast

## Angiography, Fluoroscopy, and Radiography Dose Reduction

Increase tube potential

- An increase from 60 or 65 kVp to 70 or 80 kVp will reduce dose dramatically with only minor changes in contrast
- Contrast differences barely noticeable with kilovoltage differences of 5 to 10 kVp

## Angiography, Fluoroscopy, and Radiography Dose Reduction

- Set a "floor" on kVp
- 80 kVp usually adequate for fluoro, except for pediatric patients
- 70 kVp adequate for most radiography, except for pediatric patients

## Angiography, Fluoroscopy, and Radiography Dose Reduction

*Remove the grids!!*

*Reduce the dose to 50%!!!*

Can remove grids for—

- Small fields
- Thin body parts
- Low kVp, i.e., < 70-80 kVp

## Angiography Dose Reduction

Number of images per run
- 1/sec during venous phase??
  - How about 1@2, 1/sec, 1@2, 1@4?

Number of runs (like long fluoro times!!)
- Need full run?

*Digital image exposures similar to those from screen-film systems*

## Radiographic Dose Reduction

High film density means high patient doses

Optimize film processing
- Proper time and temperature
- Use chemistry, etc. recommended by film manufacturer
- Mix chemistry in-house

## Radiographic Dose Reduction

Increase source-to-image distance
- 40” to 48” yields about 8% reduction

Use 0.6 mm focal spot!!

Improves image sharpness

## Mayo Clinic Exposures

AP Lumbar Spine

| | | |
|---|---|---|
| NEXT Median | = | 333 mR |
| 1 Q | = | 252 mR |
| 3 Q | = | 487 mR |
| Mayo Clinic | = | 225 mR |

## Mayo Fluoro Exposure Rates

PA Abdomen

| | | |
|---|---|---|
| NEXT Median | = | 5.0 R/min |
| 1 Q | = | 3.5 R/min |
| 3 Q | = | 6.8 R/min |
| Mayo Clinic | = | 0.9 R/min |

## Pay Attention to Details

| | *Dose Decrease* |
|---|---|
| Optimized processing | 12% |
| Increased SSD | 10% |
| Fiber-interspaced grid | 15% |
| Table-top transmission | 15% |

*Results in a 43% reduction in patient dose!*

*Or 57% of initial dose!!!*

## Combined Potential Dose Reduction

| | *Dose Decrease* |
|---|---|
| Increased kVp | 40% |
| Increased filtration | 35% |
| Optimized processing | 12% |
| Increased SSD | 10% |
| Fiber-interspaced grid | 15% |
| Table-top transmission | 15% |

*Results in a 78% reduction in patient dose!*

*Or 22% of initial dose!!!*

## Screen-Film To Digital Conversion

Screen-film AP lumbar spine– 225 mR

Computed radiography AP lumbar spine– 225 mR

No Change!!

## CT Dose Reduction

Adjust technique based on patient size and body part

Added filtration

No overlapping slices

Skip 0.5 to 1.0?

## Understand Protocols

HS vs HQ???

High Speed vs High Quality??

In HQ mode mAs is reduced about 30%

Slice overlap

Increases doses 33% to 300%

Image quality for body CT— HS = HQ

## CT— Adjust Techniques

Patient size—

Select technique based on equal noise level

Large patient images adequate?

Then reduce small patients by 8X

Large patient images noisy?

Increase large patients by 2X and reduce small patients by 4 X

## CT— Adjust Techniques

Reduce techniques for specific body parts

Chest- 10 X (based on literature)

Imaging air

Chest x-ray is 15 mR

Lumbar spine is 300 mR—

a 20X difference

## Low vs High kVp Techniques

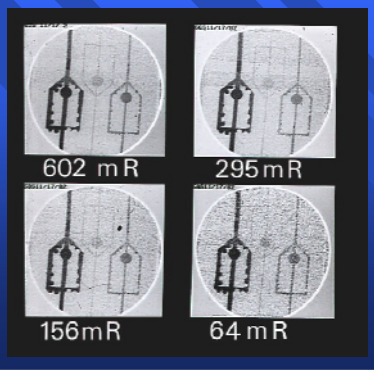
- As you increase kVp the x-ray output increases, e.g. mR/mAs
- Does this mean the dose increases?
  - For fixed mAs!!
- Increase kVp, reduce mAs—
  - To produce same noise level
  - Reduce dose to patient

## And Into the Future . . .

*All digital modalities provide the potential for excessive patient exposures!!!*

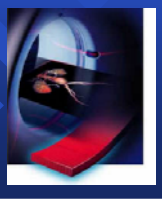
- Insist on the use of automatic exposure control or strict adherence to technique charts
- Monitor exposures on regular basis
- Collimate to body part of interest

## Noise Is Good!!

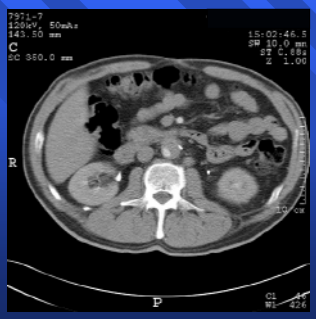



## Noise Is Good!!!

- No noise— dose too high
- Lots of noise– low dose, poor low contrast resolution
- Some noise— optimized dose and image quality



## Good Technique??

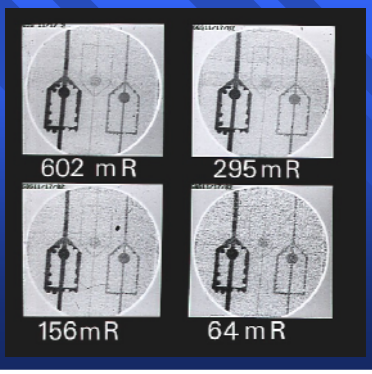


## Reduce mAs for Same Noise

| kVp | 13 cm | 20 cm | 25 cm |
|---|---|---|---|
| 80 | 50 | 350 | 800 |
| 100 | 25 | 180 | 450 |
| 120 | 19 | 100 | 300 |
| 140 | 12 | 75 | 200 |

## Good Technique??

## Noise Is Good!!



## High Dose Exams– Summary

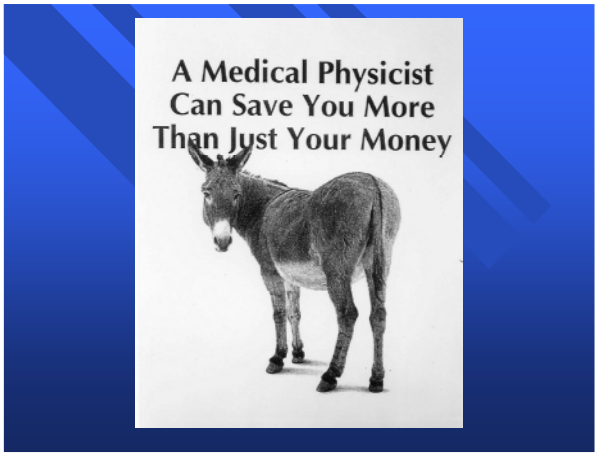
- Do you know what your doses are?
- Two important things—
  - Image quality and dose
- *Noise is Good!!*
- Caveat emptor!!
- CT is a *High Dose* exam

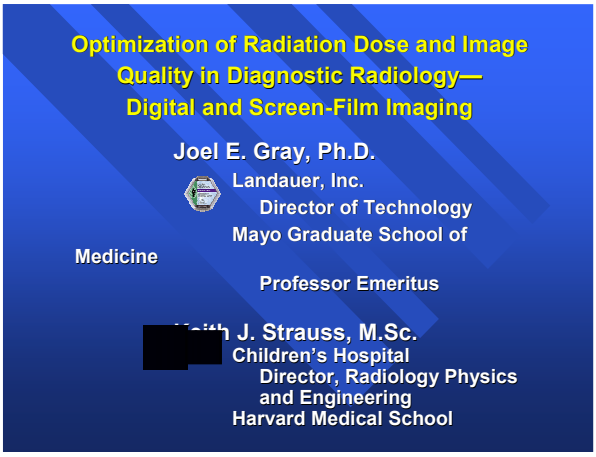
## High Dose Exams– Summary

- Pay attention to details
- Adjust techniques
  - Body size and part
- No overlapping slices!!
- Understand CT protocols

## High Dose Exams– Summary

- Use high kVp techniques
- CT fluoro is exceedingly high dose rate
  - Use intermittent mode—
  - Scan, look, adjust, scan…
- Digital imaging has potential for unlimited dose!!
- Reference values are the key
- *Noise is good!!*


A Medical Physicist
Can Save You More
Than Just Your Money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