Understanding Digital Modalities: Image Quality and Dose

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Outline

- Image Quality
  - Technique Factors
  - Post Processing
  - Image QC and Reprocessing
- Dose Control

Digital Radiography

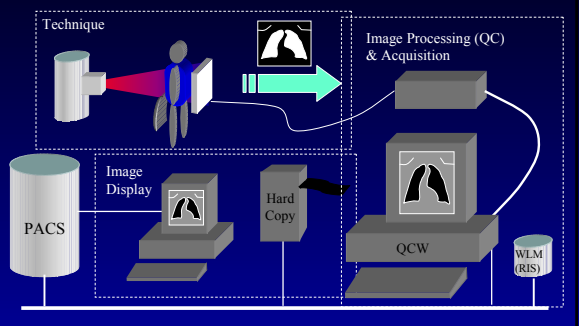


Image Quality: Fixed Grids

Moire patterns between the grid lines and the and detector sampling matrix.

- Use high grid line frequency (> 4 lines/mm)
- Some systems employ low pass filters (decreases resolution)
  - Not applicable for 8x10 or 10x12 CR views

Image Quality: Technique Factors

- Tube voltage (kV_p) selection
  - Detector energy dependence
  - Dynamic range (attenuation coefficients)
  - Patient dose
- Tube current (mA) selection
  - Motion blur
- Beam Quantity (mAs) selection
  - Detector efficiency (signal-to-noise ratio)
  - Patient dose (kV dependant)

Image Quality: Technique Factors

Detector energy sensitivity

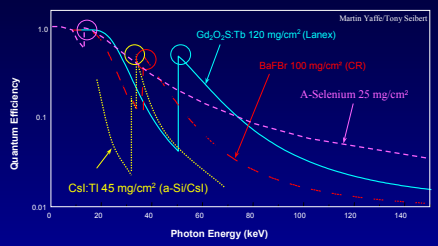


Image Quality:
Technique Factors - mAs

- Different detector sensitivity
  - New technique charts
  - Recalibrate AEC (CR and add-on DR)
- Wide dynamic range
  - Very beneficial
  - Potential downsides

Image Quality:
Technique Factors - mAs

- Under- and Over- exposure
  - Fewer photons – More noise
    - Obscures low-contrast details
  - More photons = More signal strength (signal-to-noise ratio improves)
    - Beautiful images!
    - ***High patient dose!***
- *Wide dynamic range can lead to higher patient dose!*

Image Quality:
Exposure Data Recognition

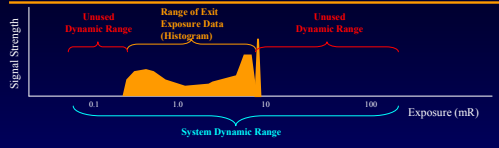
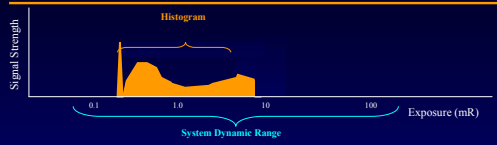


Image Quality:
Exposure Data Recognition



- Exposure data recognition failure
  - Body habitus (Pediatrics and post-surgery)
  - Patient mis-position – air peak
  - Over-collimation, gonadal shields and prosthetics
    - Special processing algorithms
    - Fixed speed techniques

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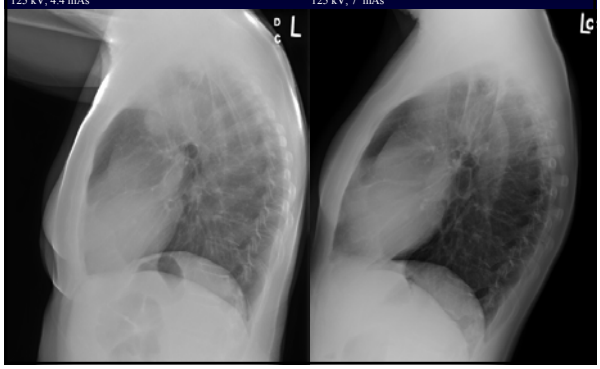
Image Quality:
Histogram Recognition

125 kV, 4.4 mAs

125 kV, 7 mAs



T- SPINE,
AP/OBLIQUE
76 kV_p
183 mAs
E.I. = 121
(E.I. = 200/mR)

T-SPINE,
AP/OBLIQUE
76 kV
137 mAs

E.I. = 12

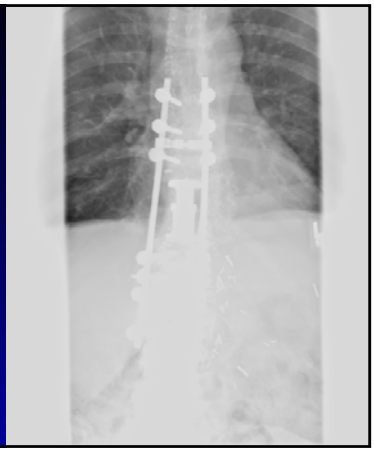


Image Quality: Processing Customization

- Reproducibility
  - Histogram variability (body habitus)
  - Post-processing by technologists
    - Frequent adjustments result in inconsistent image quality
- Vendor "looks" vs customer preferences
  - Customization is essential
  - Processing algorithm development tools

Image Quality: Image Consistency

- Image QC
  - Image rejection and limited processing only by techs
  - Default processing parameters should be password-protected
- Reprocessing at console impedes productivity
  - Dedicated workstation?
- Understand your vendor's reprocessing strategy prior to purchase

Image Reprocessing

Image Quality: QC

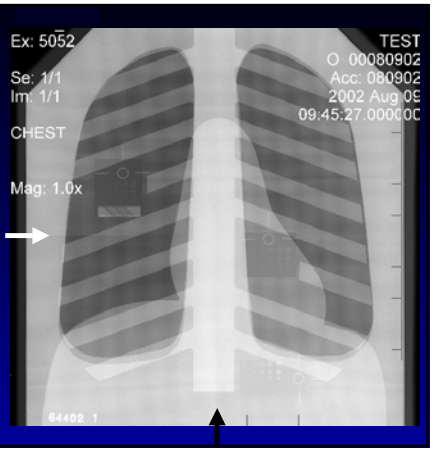


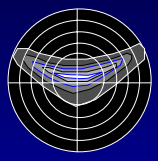
Image Quality: Display Devices

- QC at console (Manual reprocessing by tech)
  - Must assure uniform appearance at all calibrated display devices
  - Uncalibrated QC monitors
    - Images seen on PACS don't look "right"
    - Tech or PACS gets the blame for a bad QC monitor

Image Quality:
LCD Display Devices

Viewing-angle dependence of brightness and contrast
- •Asymmetries in molecular orientation within the LC layer

Some (expensive) LCD monitors correct for this:
- – Birefringent filter layers
- – Multidomain Pixels
- – In-Plane Switching
- – Combinations of above



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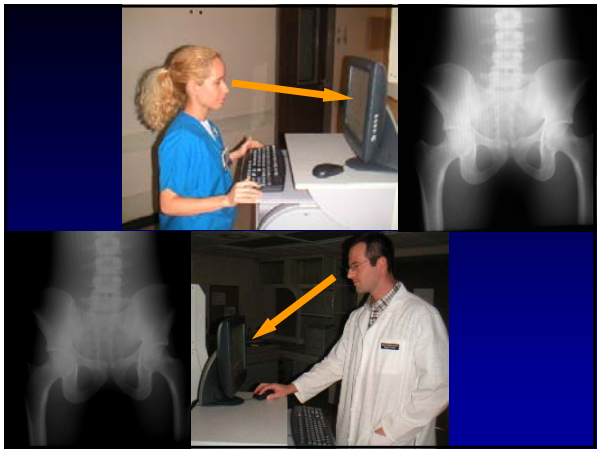

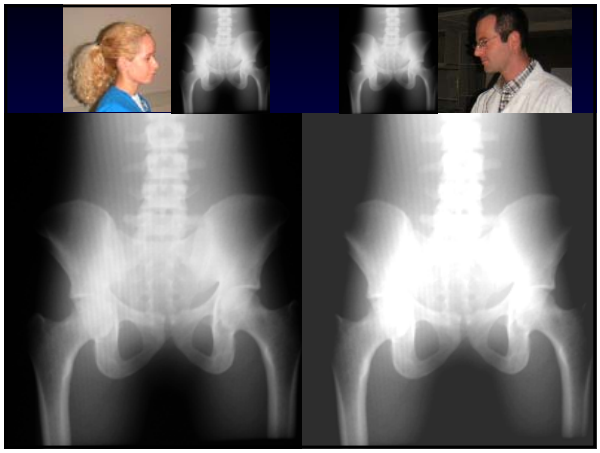

Image Quality:
LCD Display Devices

LCD is not suitable as a QC monitor *unless*:

1. The monitor is calibrated to DICOM® Part 14 (GSDF), and
2. The angular dependence of brightness and contrast is adequately corrected (high quality monitor).

® DICOM is the registered trademark of the National Electrical Manufacturers Association for its standards publications relating to digital communications of medical information.

Image Quality:
Rescale Slope and Intercept

DICOM tags that instruct PACS workstations how to display image data:

1. Rescale Slope – Linear LUT slope (usually 1)
2. Rescale Intercept - Linear LUT intercept (usually 0)
3. Rescale Type – may be a special modality LUT (usually US – unspecified)
4. Window Width and Window Level – must be set to encompass the entire histogram for the Slope, Intercept, and Type specified

Dose Control:
Exposure Index

- Technologist Feedback – Exposure Indicators (E.I)
  - Lgm value (Agfa CR) – Logs available for review
  - "S" Number (Fuji CR)
  - Exposure index (Kodak CR)
  - REX Number (Canon DR)
- Exposure to the *detector*
  - Accurate and consistent (reproducible)
  - Patient exposure index (DAP or EE) – not the same!
- QC? - Exposure Index Log

Dose Control: Image Consistency

- Consistency of E.I. is essential
  - A complete understanding of Exp. Index and histogram recognition is needed to avoid frustration and confusion
  - Repeats only work if the processing method is changed (fixed mode)

Every repeat doubles Pt. exposure!!

Summary

- Wide Dynamic Range
  - Exposure indices – not image density!
- Rules for Pedi's
  - Technique charts
  - Special processing
- Prosthetics & gonadal shielding – impact on histogram recognition
- Strategy for reprocessing
  - Who?
  - Where?

Summary

- Quality Control
  - Equipment
  - Repeat/Reject analysis (Exp. Index log)
- Dose Control
  - Reliable Exposure Indices
  - Calibrated AEC devices
    - kV compensation
    - Exposure rate compensation (thickness and mA)

Bibliography

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- Seibert
- Digital Imaging and Communications in Medicine (DICOM), National Electrical Manufacturer's Association (NEMA), 1300 N. 17th Street, Suite 1847, Rosslyn, VA, 22209.
- Samei E, et al, Acceptance Testing & Quality Control of Electronic Devices for Soft-copy Display, AAPM (Draft document), http://deckard.mc.duke.edu/~samei/tg18
- Thompson SK, Willis CE, Krugh KT, Shepard SJ, and McEnery KW. Implementing the DICOM Grayscale Display Function for Mixed Hard- and Soft-copy Operations. Journal of Digital Imaging 15(Suppl 1):27-32, 2002.
- Honea R, Blado ME, and Ma Y, Is Reject Analysis Necessary after Converting to Computed Radiography?, Journal of Digital Imaging 15 Suppl 1, 2002 pp 41-52.

More Information

- AAPM 2004 Summer School
  - PACS Basics for Radiographic and Fluoroscopic Systems *(Jeff Shepard)*
  - Softcopy Display Technology, Specifications, Performance Evaluation and QC *(Michael Flynn)*
  - Clinical Issues with Digital Radiographic and Fluoroscopic Systems *(TBD)*
  - Exposure Indicators and AEC Performance Testing with DR and CR (*Lee Goldman)*
  - Hardcopy Technology, Specifications, Performance Evaluation and QC (TBD)

More Information

- RSNA 2004 x25 - Update Course: Advances in Digital Radiography
  - 525: Digital Radiographic Implementation Considerations (Flynn, Clunie, Shepard)
  - 425: Digital Radiographic Image Quality (Ravin, Holsbeeck & Flynn, Bedano)
  - 325: Digital Radiographic Display Considerations
- RSNA 2004 326 – PACS Acquisition, Display Technology and DICOM
- RSNA 2004 324 – Radiation Safety and Risk Management Minicourse: Optimizing Adult and Pediatric Diagnostic Image Quality and Radiation Exposure