Transition from screen-film to digital radiography: Practical Advice

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1. Introduction
2. Issues in Digital Imaging
3. Image Acquisition
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1. Introduction

“ While digital techniques have the potential to reduce patient doses, they also have the potential to significantly increase them.”

- ICRP 93 Editorial

"This is a technology that is advancing rapidly and which will soon affect hundreds of millions of patients.

If careful attention is not paid to the radiation protection issues of digital radiology, medical exposure of patients will increase significantly and without concurrent benefit."

- ICRP 93 Editorial

- Most principles for dose reduction for screen-film radiography, especially *justification*, are relevant to digital systems
- However, in digital systems different scenarios apply for dose reduction and optimisation compared with screen-film radiography

Screen-Film Radiography

Digital Radiography

Recording

Displaying

Archiving

Digital detector

Display Monitor

PACS server

Major limitation is 'film'

Optimize each component independently

KH Ng

- The diagnostic information provided by modern digital detectors can be equal or superior to conventional screen-film systems, with comparable patient doses.
- Digital imaging has practical technical advantages compared with film techniques, e.g. wide contrast dynamic range, post-processing functions, multiple image viewing options, and electronic transfer and archiving possibilities.

2. Issues in digital imaging

"This is a technology that is advancing rapidly and which will soon affect hundreds of millions of patients.

If careful attention is not paid to the radiation protection issues of digital radiology, medical exposure of patients will increase significantly and without concurrent benefit."

[We are witnessing the consequences now]

- ICRP 93 Editorial

bmj.com

X ray imaging goes digital

Kwan-Hoong Ng and Madan M Rehani

BMJ 2006;333;765-766
doi:10.1136/bmj.38977.669769.2C

X ray imaging goes digital

Digital imaging brings benefits but also demands changes in ways of working

Digital x ray imaging has brought obvious benefits to health care, but, as with all new technologies, it both requires and leads to changes in behaviour and processes, some obvious and some less so. The issues include cost and productivity,

images not as acceptable as film for interpretation.[4] Today, high resolution displays have greatly aided interpretation of digital images.

It was once thought that digital systems would reduce radiation doses. They can facilitate dose

Digital imaging brings benefits but also demands changes in ways of working

Digital x ray imaging involves issues

- cost and productivity
- need to acquire new skills
- radiation doses
- overuse
- image quality

It is easy to delete digital images, and repeat exposures normally go undetected.

Ng BMJ 2006

Different imaging tasks require different levels of image quality.

e.g. the follow-up examination

for a fracture does not require the same image quality as that required for its diagnosis.

Ng BMJ 2006

Current issues with clinical digital radiography: Human Factors

- Inappropriate exposure
- Increase in number of examinations
- No (inadequate) collimation
- Image quality is not compatible with imaging task

Inappropriate exposure

- With digital systems, an overexposure can occur without an adverse impact on image quality.
- Overexposure may not be recognised by the radiologist or radiographer. In conventional radiography, excessive exposure produces a “black” film and inadequate exposure produces a “white” film, both with reduced contrast. In digital systems, image brightness can be adjusted post processing independent of exposure level.

Increase in number of examinations

In several U.S. hospitals the number of examinations per in-patient day increased by 82% after a transition to film-less operation.

Outpatient utilization (i.e. the number of examinations per visit) increased by 21% compared with a net decrease of 19% nationally at film-based hospitals.

Reiner et al. Radiology. 2000 ;215(1):163-7

3. Image Acquisition

- Positioning
- Collimation & Electronic Masking
- Anatomic Side Makers
- Exposure Technique (kVp/mAs)
- Anatomically Programmed Radiography (APR) & Exposure Technique Chart
- Automatic Exposure Control (AEC)
- Grid
- Shielding

Positioning

Positioning errors is the *number one* reason for repeat digital radiography examinations.

Increase in exposure latitude in digital radiography leads to overall reduction in repeats. Cause of most repeat imaging has shifted to positioning errors. Inaccurate positioning of the part relative to the image receptor, along with a poorly collimated exposure field, often results in poor quality digital images.

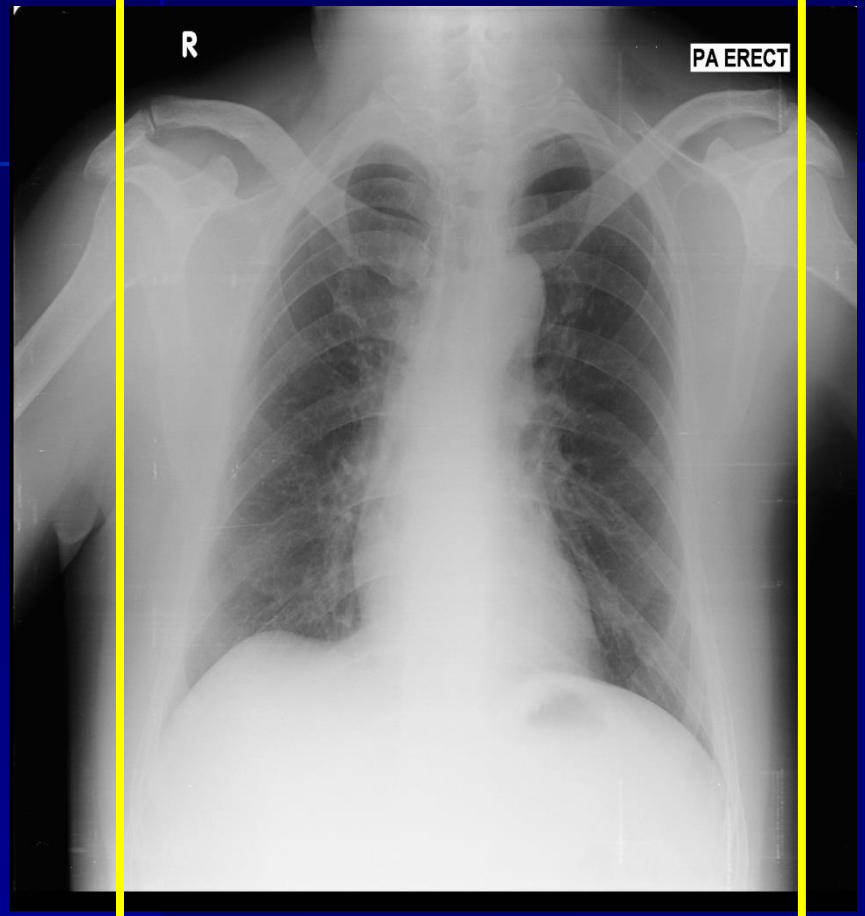
For peadiatric patients - Immobilization is a critical component of positioning that helps to prevent retakes.

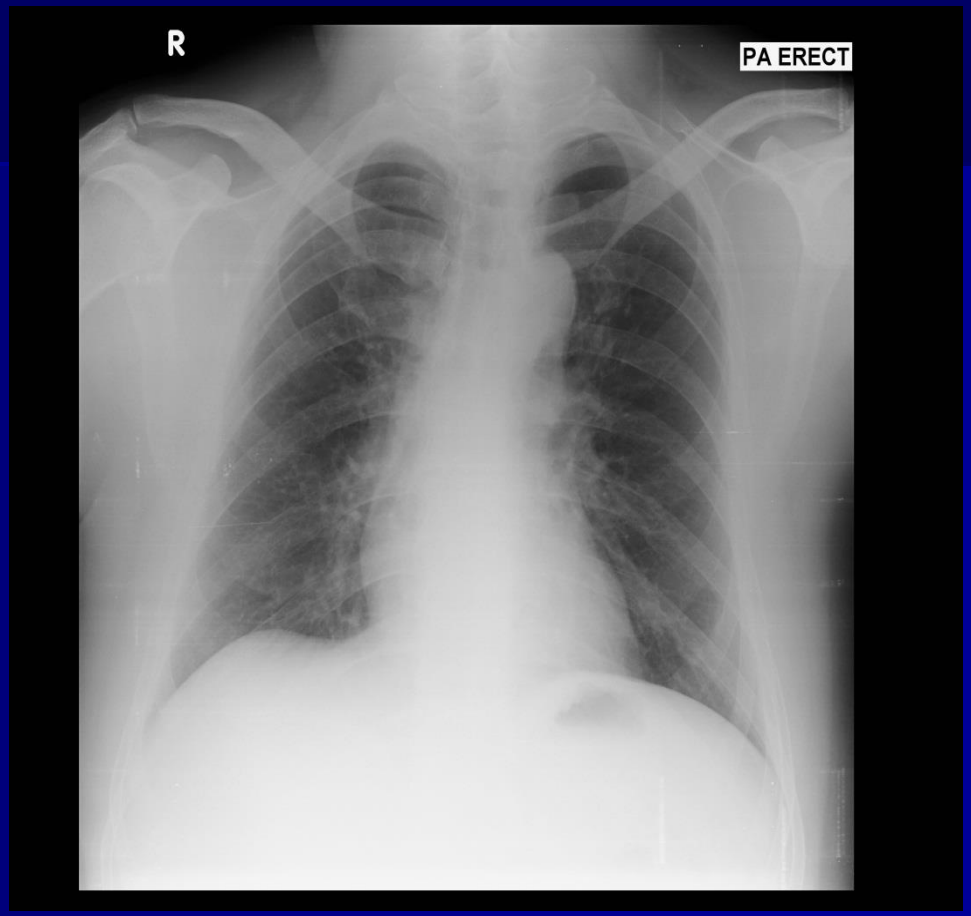
A best practice use immobilization devices when needed prevent repeat exposures by appropriately positioning the patient.

Collimation & Electronic Masking

No collimation

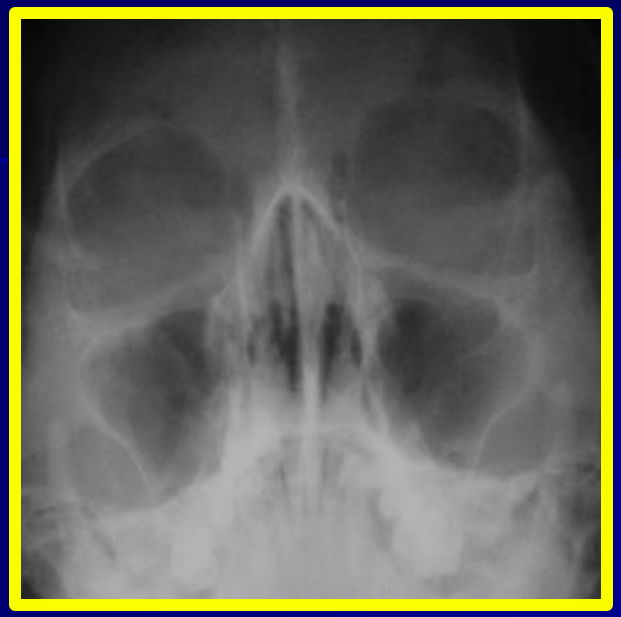
Or too broad the collimation size





Post-exam collimation (cropping)

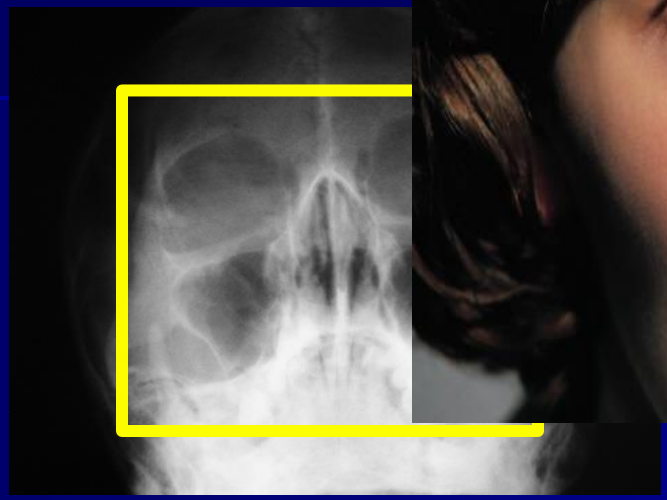
No collimation



Apparently "Perfect" radiographs of the paranasal sinuses with post exam cropping

Courtesy Dr. Evelyn Ho, SDMC

No collimation



A series of radiographs which were supposed to be for the paranasal sinuses (yellow collimation lines) but instead practically the whole head was x-rayed!

Courtesy Dr. Evelyn Ho, SDMC

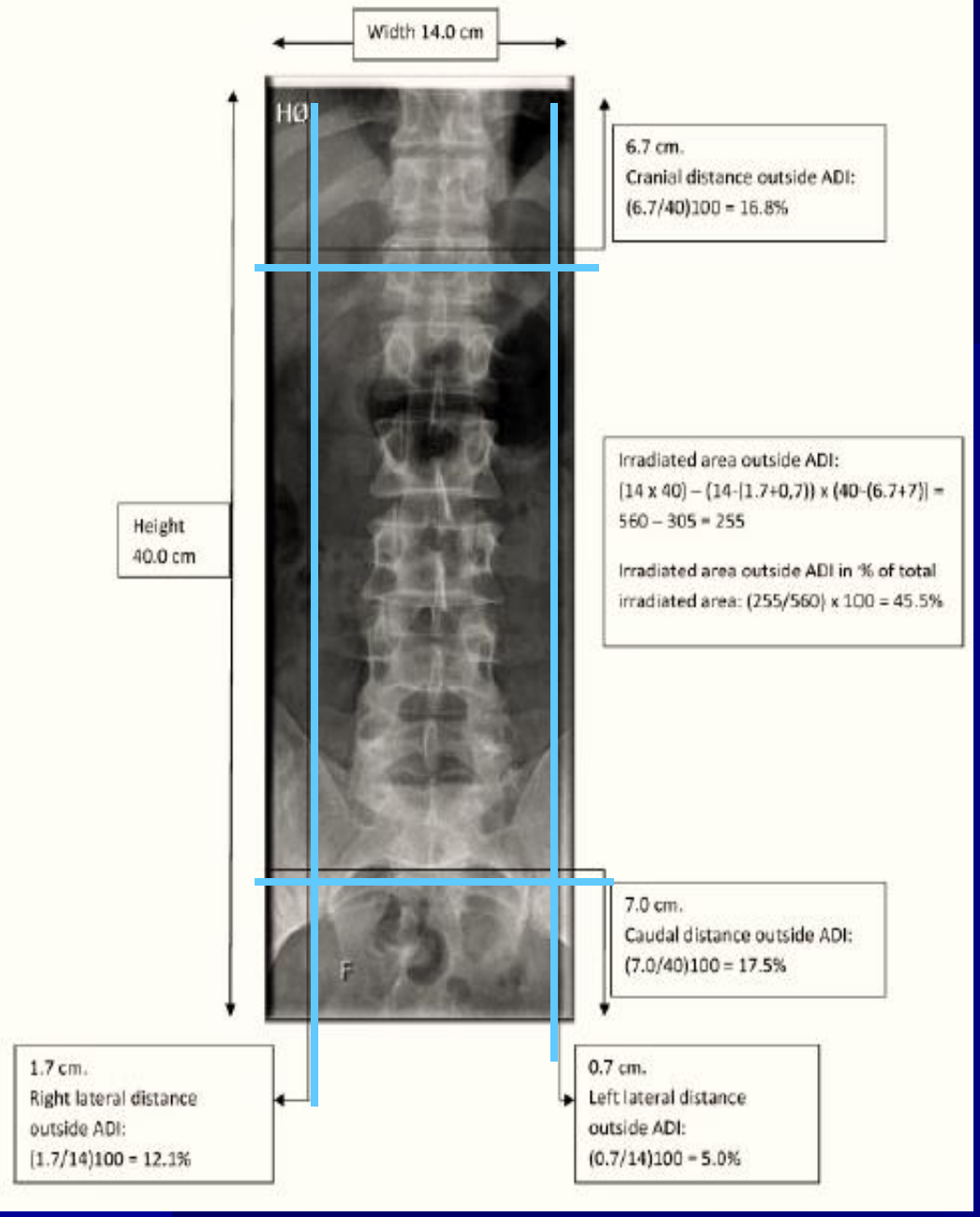
No collimation

What happens to collimation?

Lumbar spine radiography – poor collimation practices after implementation of digital technology

Zetterberg and Espeland
Brit J Radiol, 84 (2011), 566–569

No collimation



Lumbar spine radiography - poor collimation practices after implementation of digital technology

	Digital	Analog (Film)
Irradiated field outside ROI	61.7%	42.4%
Total field size	791 cm^2	541 cm^2

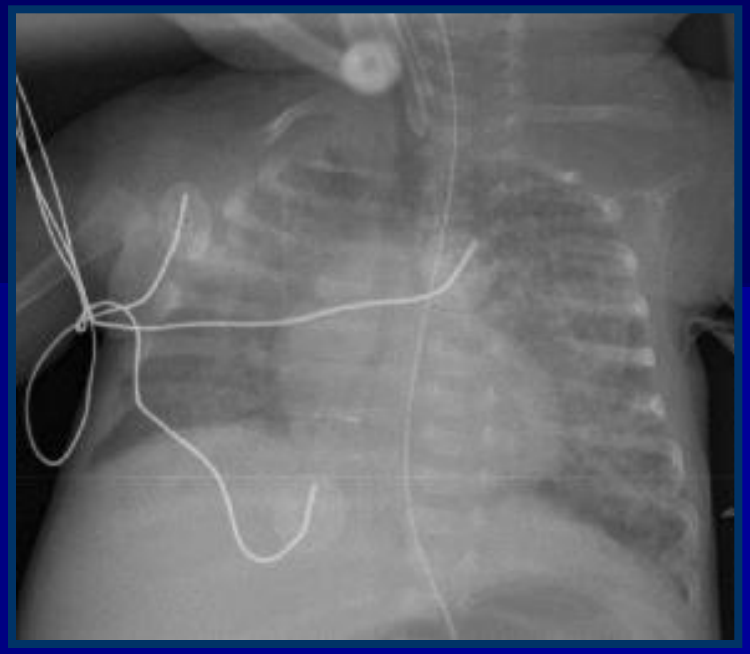
Zetterberg and Espeland Brit J Radiol, 84 (2011), 566–569

No collimation

A survey of 450 technologists by the American Society of Radiologic Technologists (ASRT) revealed *that half of the respondents used electronic cropping after the exposure*

Pediatric Radiology, 2011, 41:5, 602-610

No collimation



- Poor collimation
- Large part of the body is irradiated
- Not seen on digitally cropped image

The Art of Collimation

- Some machine has automatic collimation to detector size – not practical for smaller size patient (e.g. Asia). Omit the use or disable this feature.
- Learn to use anatomical landmarks for collimation guide
- Always refer to old x-ray image when doing follow-up examination, helps to define collimation size
- Correct placement of anatomical marker- helps to reduce collimation size

The Dilemma of Collimation

Radiographers have dilemma in tight collimation-

1. Fear of cutting the ROI- hence: Basic rule – better to be large than cut the ROI.
2. The gap between theory and practice

   e.g. Lumbar spine

In theory: ROI to include T12 to S1

In practice: Doctor may want to see from lower thoracic spine to coccyx.

The Dilemma of Collimation

- Radiographers have developed the practice *(habit)* to include more anatomical structures (especially in trauma cases) to avoid repeat or retake radiographs due t
  accurate/ less precise
  request from doctors.

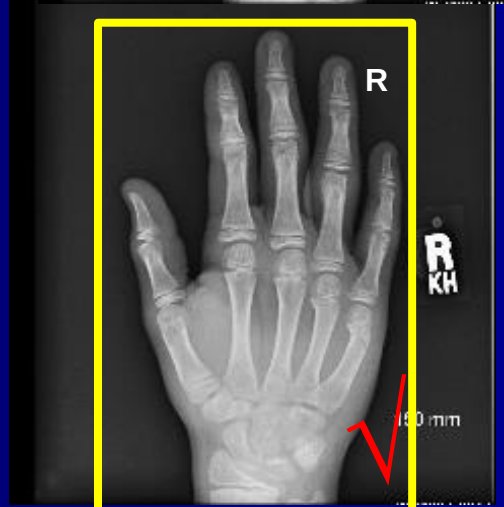
Anatomical Side Marker

- Most radiographic technique books emphasise that it is mandatory to place an anatomical side marker for every radiograph.
- Radiographers are taught the correct way of placing the marker in practice.

Collimation & anatomical marker

- Sometimes due to the ineffective placement of anatomical side marker, collimation size is compromised to include the marker.
- Strategically place the anatomical side marker can help to improve collimation.

Collimation & anatomical marker



Standardized Exposure Technique

- Department cannot depend solely on vendors to set exposure standards
- Setting policies and protocols ensure consistency in image quality and dose optimization
- Radiographer with sound knowledge should work together with vendor during automatic exposure setting.

AEC

- Radiographers must have sound knowledge of how AEC works to be effective in dose optimization.
- Selection of correct sensor field
- Accurate positioning of ROI to sensor field
- Take note on examination part- smaller than sensor field – should not use AEC
- Total knee replacement- try not to use AEC – over exposure may happen if metal part is placed over sensor field.

AEC

The wide exposure dynamic range of such systems may have the disadvantage that, if the X-ray generator AEC develops a fault or the output calibration drifts, the dose increase/decrease may not be identified readily.

Also, the wide exposure dynamic range means there is significant potential for the initial set-up of such systems not to be optimised.

AEC Calibration

- Physicists have to be sure that the AEC is calibrated accordingly to digital system and not based on screen/film
- To properly exposure digital radiographs, recalculate the kVp correction curve to AEC system to response correctly to the receptor characteristics is necessary.

Anatomically Programmed Radiography & Exposure Technique Charts

Anatomically Programmed Radiography (APR)

A system of preprogrammed exposure technique settings that is organized by position and procedure and set through the control panel of the radiography unit.

APR settings provide recommendations for small, medium and large adult patient sizes and include a combination of AEC and manual exposure technique settings.

Exposure Technique Charts

To standardize exposure techniques according to patient size, procedure and position.

- provide consistent and accurate radiation exposure to the image receptor.
- Establish department standards and eliminates confusion and concern regarding appropriate use of kVp, mA, grid use and SID.
- Allow radiologists and radiographers to work together to set an acceptable level of radiation exposure that provides diagnostic quality images within the ALARA principle.

Exposure Technique Charts

The charts don't take the place of radiographers carefully assessing individual patient pathology, condition and unusual circumstances because the charts are designed for the average or typical patient.

Exposure technique charts should be monitored and revised continuously to ensure these techniques are producing diagnostic images within the ALARA principle.

A thorough exposure technique chart includes these variables for each x-ray tube:

- Backup exposure time or mAs (if set).
- Source-to-image receptor distance (SID).
- kVp.
- Focal spot size.
- mA (if set).
- Use of a grid and the grid ratio.
- AEC detector(s).
- Acceptable exposure indicator range.

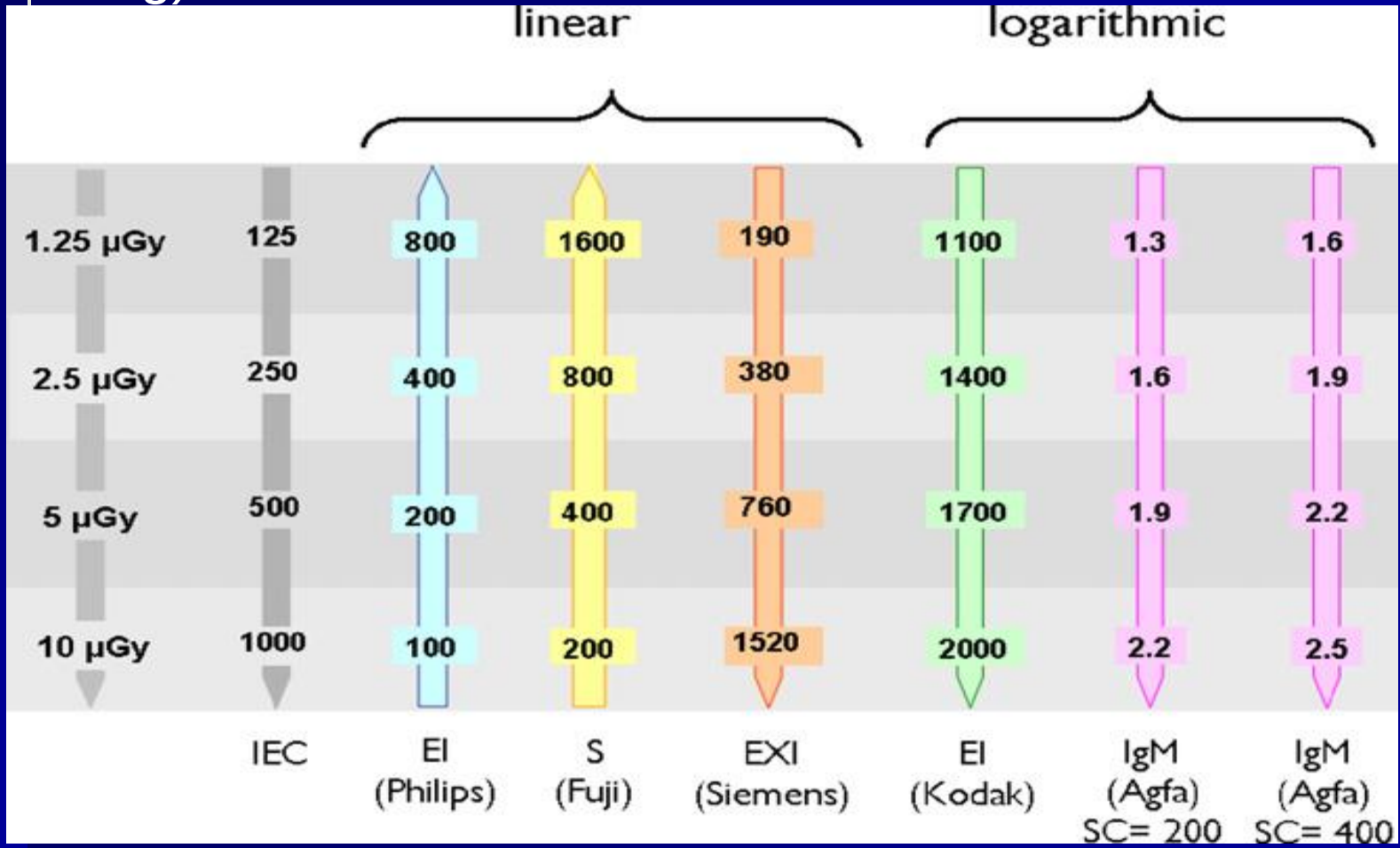
A best practice in digital radiography is to use exposure technique charts that are continuously improved and applicable to a wide range of patient sizes.

Exposure (sensitivity) Index

Each image should ideally have an associated number to indicate the level of exposure to the detector. Currently all digital systems have a exposure (sensitivity) index which is related to detector exposure.

Once digital radiography systems are in use, the constancy of applied exposure factors should be monitored on a regular basis.

List of terms for exposure indices for various digital systems and their relationship to traditional dose measure (in µGy). In the 2nd column the proposal for an international standardisation is detailed (courtesy of Ulrich Neitzel, Philips Medical Systems, Hamburg).



Uffmann et al E J Radiol 72 (2009) 202–208

New Exposure Indicators for Digital Radiography Simplified for Radiologists and Technologists

Steven Don[1], Bruce R. Whiting[2], Lois Jo Rutz[3] and Bruce K. Apgar[4]

Am J Roentgenol. 2012 Dec;199(6):1337-41

Both the IEC (IEC standard 62494-1) and the AAPM (AAPM Task Group 116) have developed similar standards for monitoring exposure in digital radiography to eliminate proprietary and confusing terminology.

Radiologists and technologists will need to learn three new terms - exposure index, target exposure index, and deviation index - to understand the new standards.

Grid

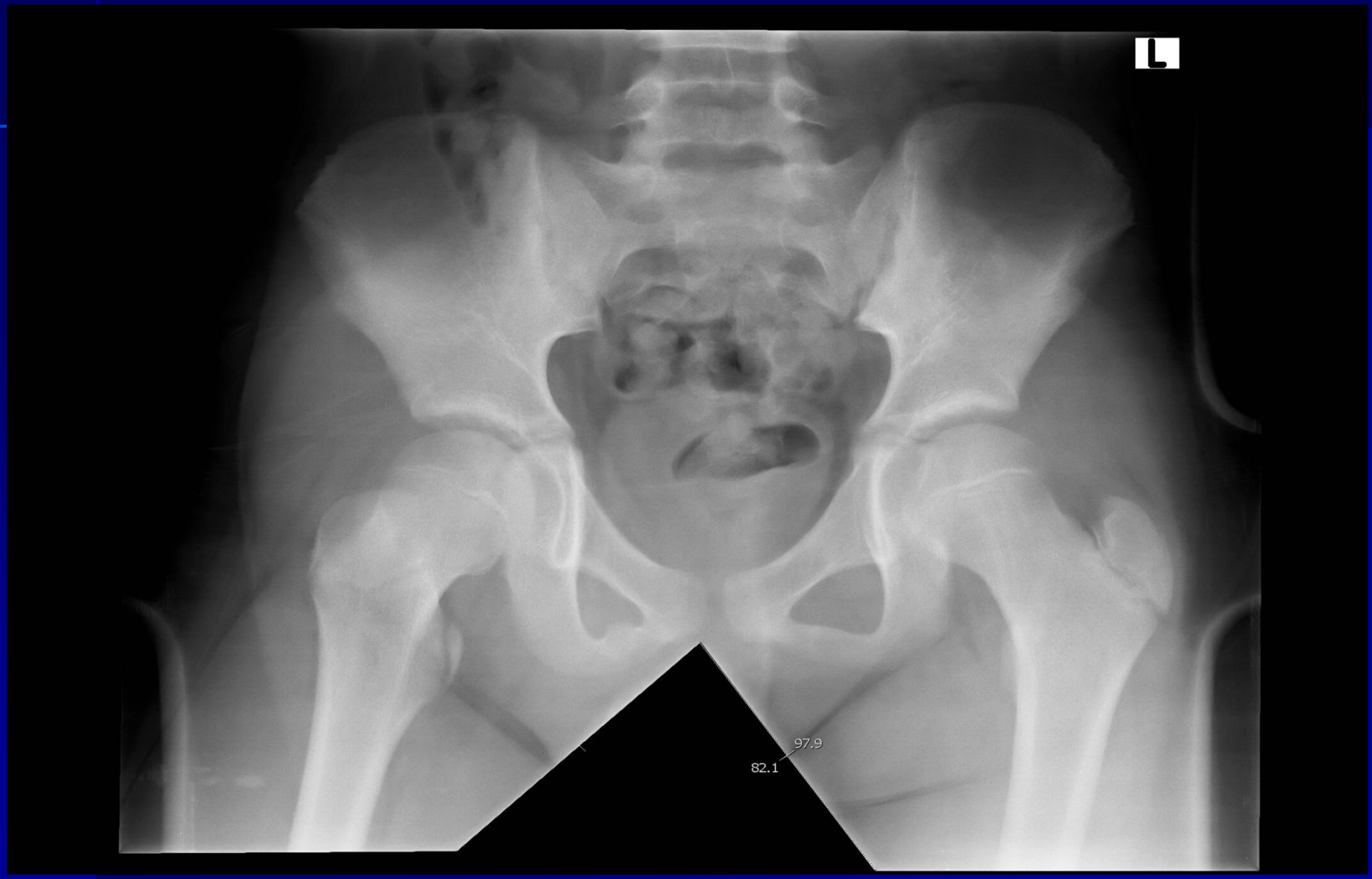
Digital imaging is more sensitive to low-level radiation exposure, thus the need to use antiscatter grids. It results in increase in patient dose.

Grids are appropriate for anatomy that is > 10 cm thick & for kVp settings of > 70.

Shielding

Creative ‘shielding’

Shielding



Educate, Educate, EDUCATE

Train, Retrain, Train, RETRAIN

Collimation is urgently needing attention

Thanks to

Lai-Kuan Chan, MSc (Health Science)

Napapong Pongnapang, PhD

For their advice