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Radiation protection of patients and the use of Diagnostic Reference Levels in digital radiology

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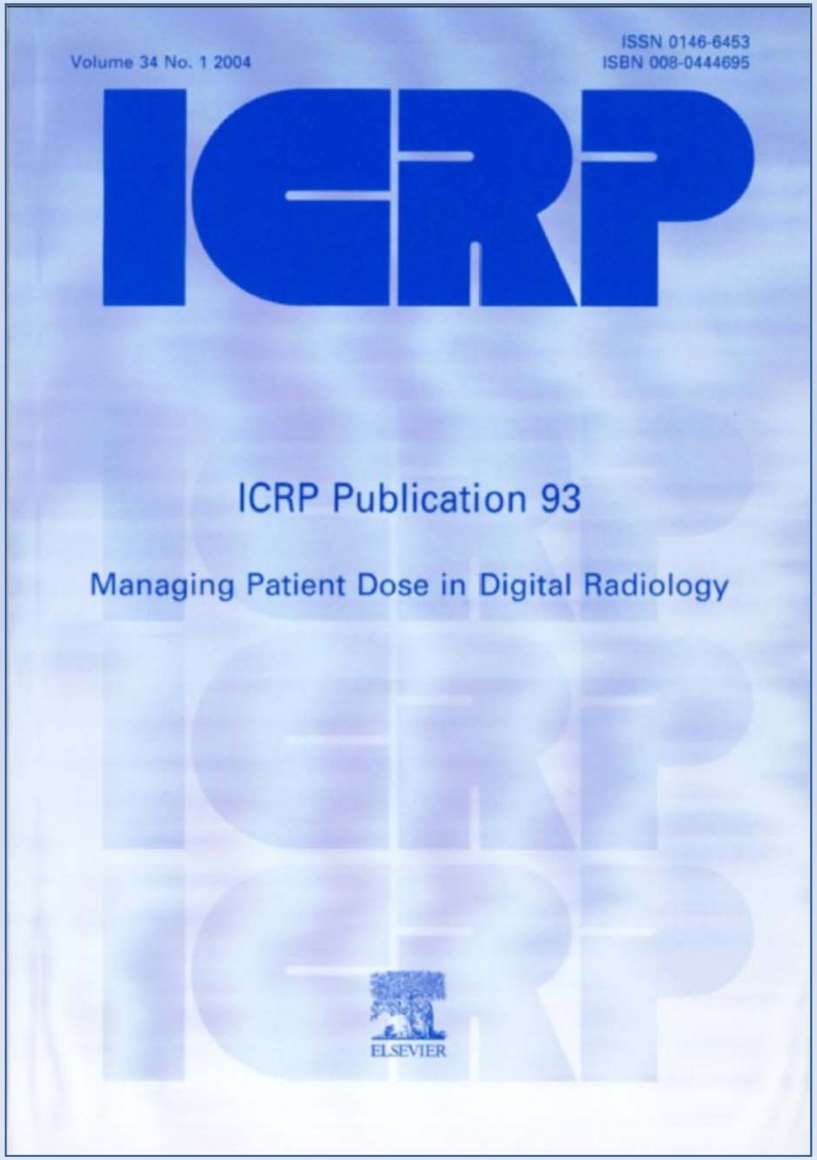
Sunday, 1st September
14:30 – 15:00

Contents

1. ICRP and Digital Radiology (DR).
2. DR and the potential increase of overusing radiation.
3. Advantages of Digital Radiology.
4. Need of specific training.
5. Patient dose calculation and registry.
6. Special aspects of commissioning.
7. Justification and optimization in DR.
8. Diagnostic Reference Levels (DRLs) present and future.

ICRP and Digital Radiology



- The International Commission on Radiological Protection (ICRP) published in 2004 a document on ***'Managing patient dose in digital radiology'***.

INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

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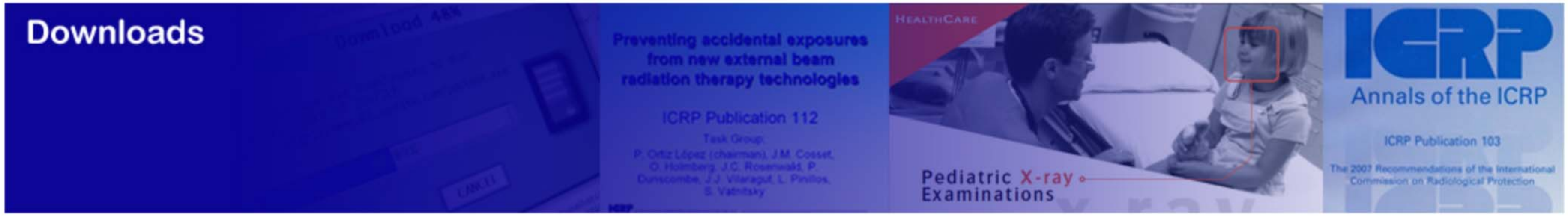
Downloads



- Free Summary Recommendations
- Free ICRP Posters: Paediatric radiology
- Free Guides and Explanatory Notes
- **Free Educational Downloads**
- Free Educational CD Downloads

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Free Educational Downloads

The following files are downloadable here at no cost. They can be used by teachers, doctors, and those interested in radiological protection in medicine, together with recent medical reports.

Please note that while we encourage you to download and use these modules, ICRP has the copyright and you must not edit or try to sell the files.

- ICRP 84, Pregnancy and medical radiation (1.3 Mb)
- ICRP 84, Pregnancy and medical radiation, Spanish version (2.3 Mb)
- ICRP 85, Interventional radiology (1.4 Mb)
- ICRP 86, Accidents in radiotherapy (0.8 Mb)
- ICRP 86, Accidents in radiotherapy, Spanish version (0.6 Mb)
- ICRP 87, CT dose management (0.6 Mb)
- ICRP 93, Digital radiology (1.2 Mb)
- ICRP 93, Digital radiology, Spanish version (1.2 Mb)
- ICRP 112, Preventing accidental exposures from new external beam radiation therapy technologies (0.8 Mb)
- ICRP 112, Preventing accidental exposures from new external beam radiation therapy technologies, Spanish version (0.9 MB)

In order to be able to read these, you need the "Adobe Acrobat Reader". If you do not already have the reader, you can download it, free of charge, here.

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In order to be able to read Powerpoint-files, you need Microsoft Office

Digital Radiology and the potential increase of overusing radiation

- Digital techniques offer great potential for better practice in radiology but also increase the risk of overusing radiation.
  - **Increase in frecuency.**
  - **Increase in patient dose / procedure.**

Radiology

Transition from Screen-Film to Digital Radiography: Evolution of Patient Radiation Doses at Projection Radiography[1]

Vano E,
Fernandez JM,
Ten JI et al.

Radiology: Volume 243: Number 2—May 2007

- **A database with 204,660 patient dose values was used to compute changes in patient doses over time.**
- **First, INCREASE: Median values for patient entrance doses increased 40%-103% after implementation of CR (2001).**
- **Later, DECREASE: At present, doses range between 15% and 38% of the European DRLs established for screen-film radiography and between 28% and 41% of the reference values recommended by the AAPM.**

ICRP: Increase in the number of examinations with digital …

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.

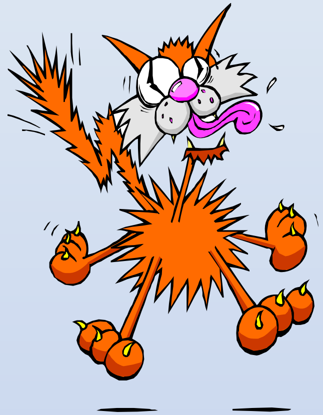
Reiner et al. Radiology. 2000 Apr;215(1):163-7

Increase in the number of examinations with digital (also in paediatrics)…

- Implementation of digital radiography in a neonatal intensive care unit (Pediatric Radiology, C.S. Mott Children's Hospital, University of Michigan Medical Center).
- To investigate variations in radiation exposure after the implementation of digital radiography in a neonatal intensive care unit.
- Accounting for variations in the patient’s burden of illness, **there was an increase in the number of portable radiographs per patient (+ 8.1%)**.

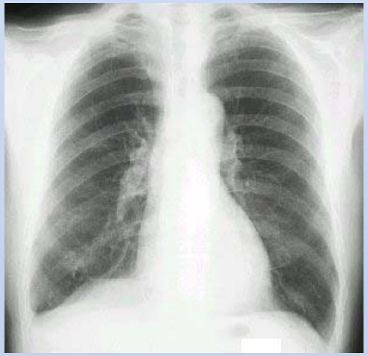
Sanchez R et al. Proceedings of the IAEA Bonn Conference 2012.

Some risk during routine work



- **With digital systems, an overexposure can occur without an adverse impact on image quality.**
- **Overexposure may not be recognised by the radiologist or radiographer.**

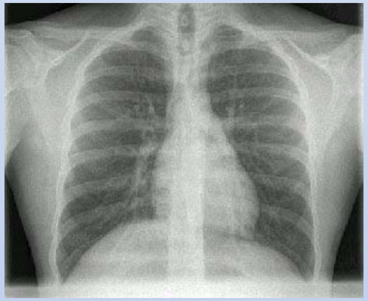
Conventional film - screen



Entrance dose: 0.2 mGy

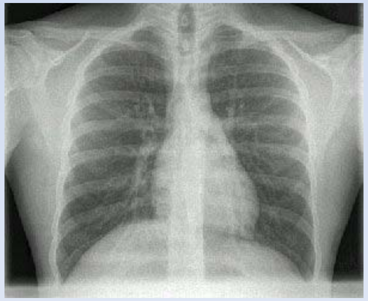
Overexposure (0.8 mGy) is clearly detected

Digital (CR)



Entrance dose: 0.2 mGy

Overexposure (0.8 mGy) is not easily detected



Advantages of DR

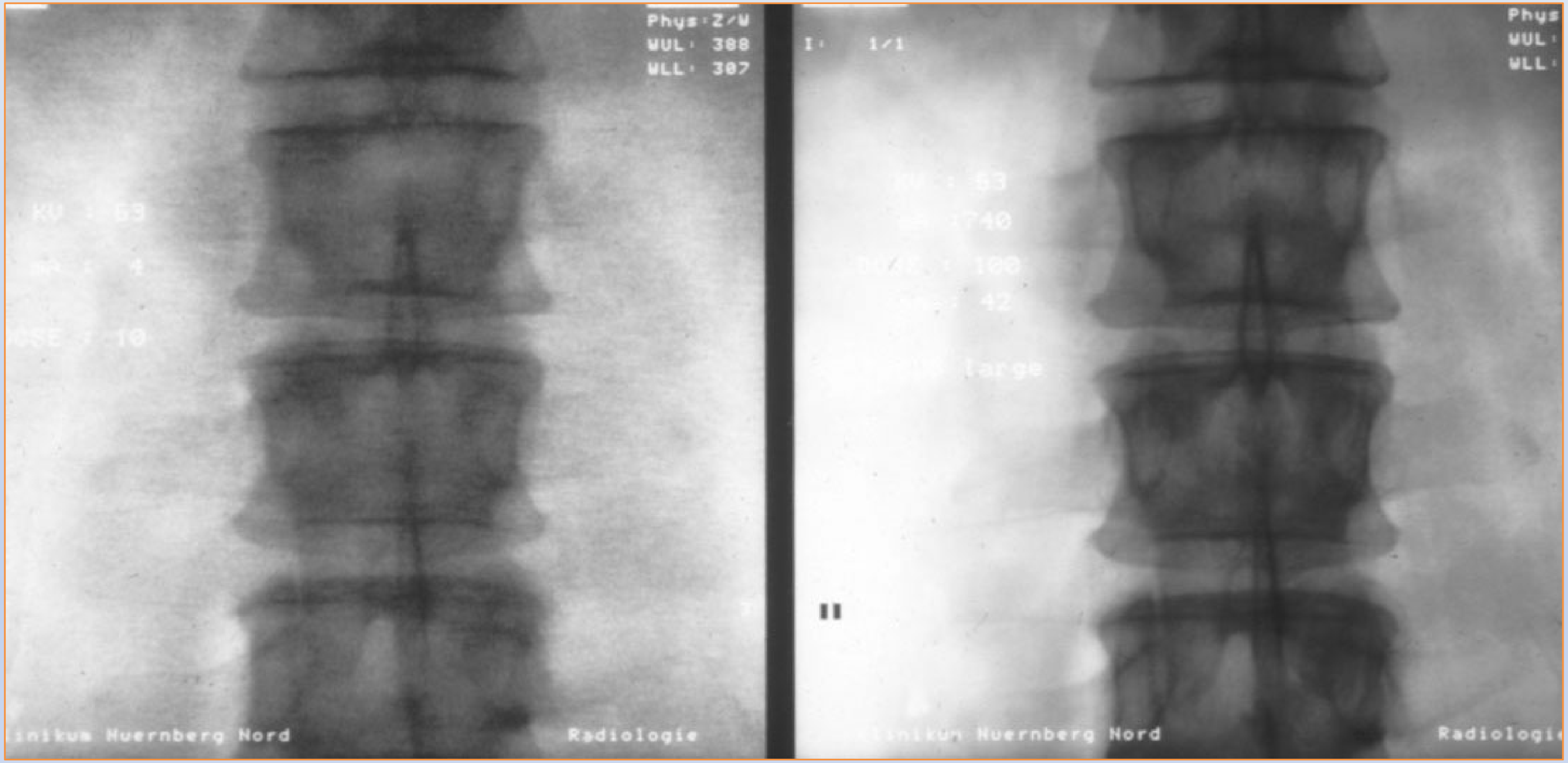
- The main advantages of digital imaging:
  - wide dynamic range,
  - post-processing,
  - multiple viewing options,
  - electronic transfer and archiving possibilities,

Need of specific training

- Digital radiology requires specific training for radiologists, radiographers and medical physicists.
- Different medical imaging tasks require different levels of image quality.
- The objective is to avoid unnecessary patient doses; doses which have no additional benefit for the clinical intended purpose.

CLINICAL PROBLEM	IMAGE QUALITY CLASS	COMMENT
Primary bone tumour	High	Image may characterise the lesion.
Chronic back pain with no pointers to infection or neoplasm	Medium	Degenerative changes are common and non-specific. Mainly used for younger patients (e.g. less than 20 years of age, spondylolisthesis etc.) or older patients e.g. greater than 55 years of age.
Pneumonia adults: follow-up	Low	To confirm clearing, etc. Also, not useful to re-examine patient at less than 10-day intervals as clearing can be slow (especially in the elderly).

Proposed by P. Busch et al. (DIMOND and SENTINEL European Actions)



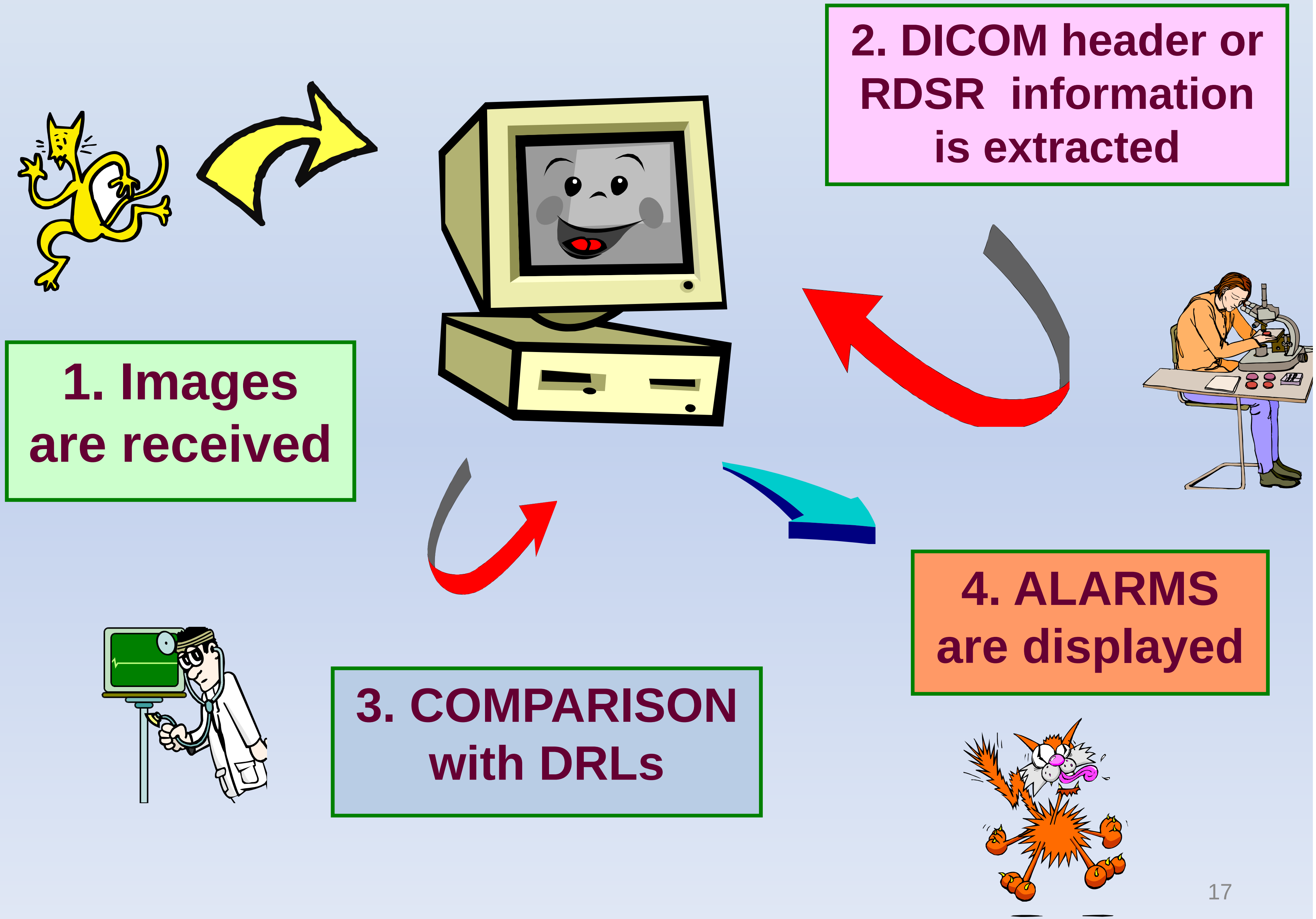
Digital image of lumbar spine. Fluoroscopy system: 10% dose (left); 100% dose (right) (relative values of dose).
Courtesy of R. Loose.

Patient dose registry (1)

- Patient doses can be easily estimated, registered and transferred to the patient examination reports (and data bases).
- Image quality (or diagnostic information) should be tailored to the clinical problems.
- But periodic calibration and audit by medical physicists are necessary.
- Potential problems with dose quantities, dose units, geometry, etc.

Patient dose registry (2)

- ICRP recommended in 2004 that industry should promote tools to inform radiologists, radiographers and medical physicists about the exposure parameters and the resultant patient doses.
- The exposure parameters and the resultant patient doses should be standardized, displayed and recorded.


2. DICOM header or RDSR information is extracted
1. Images are received
4. ALARMS are displayed
3. COMPARISON with DRLs

Some parameters that may be audited from the DICOM header or RDSR

1. Patient entrance dose (entrance air kerma).
2. Dose area product (and collimation).
3. Radiographic technique (e.g. appropriate kVp).
4. Appropriate use of the AEC.
5. Appropriate breast compression in mammography.
6. Flat panel detector temperature.
7. Number of series, number of images per series, kV, mA, ms and total number of images per procedure.
8. Exposure index and postprocessing parameters (for CR).
9. Repeated images (retakes).
10. Image quality (basic evaluation).

2013

Medical Physics and Informatics • Review

AJR FOCUS ON:

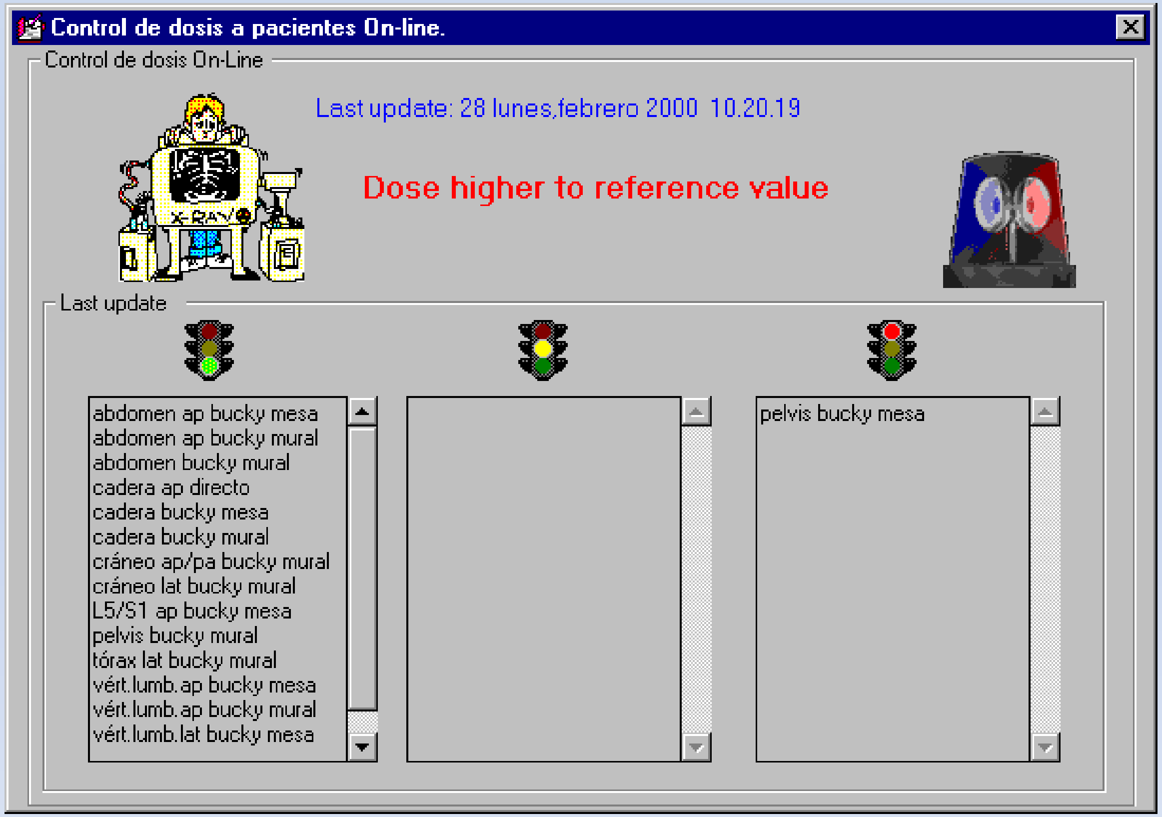
Experience With Patient Dosimetry and Quality Control Online for Diagnostic and Interventional Radiology Using DICOM Services

Eliseo Vano[1,2]
Jose I. Ten[2,3]
Jose M. Fernandez-Soto[1,2]
Roberto M. Sanchez-Casanueva[1]

OBJECTIVE. This article describes the different automatic approaches used to collect and process patient dose values and other procedural data during diagnostic and interventional radiology and discusses their benefits for clinical practice and quality control online. Approaches for automatic processing of patient dose and other procedural data for computed radiography and for flat-panel detectors extracting information from DICOM headers or via DICOM services are described. The method to perform image retake analysis is also discussed.

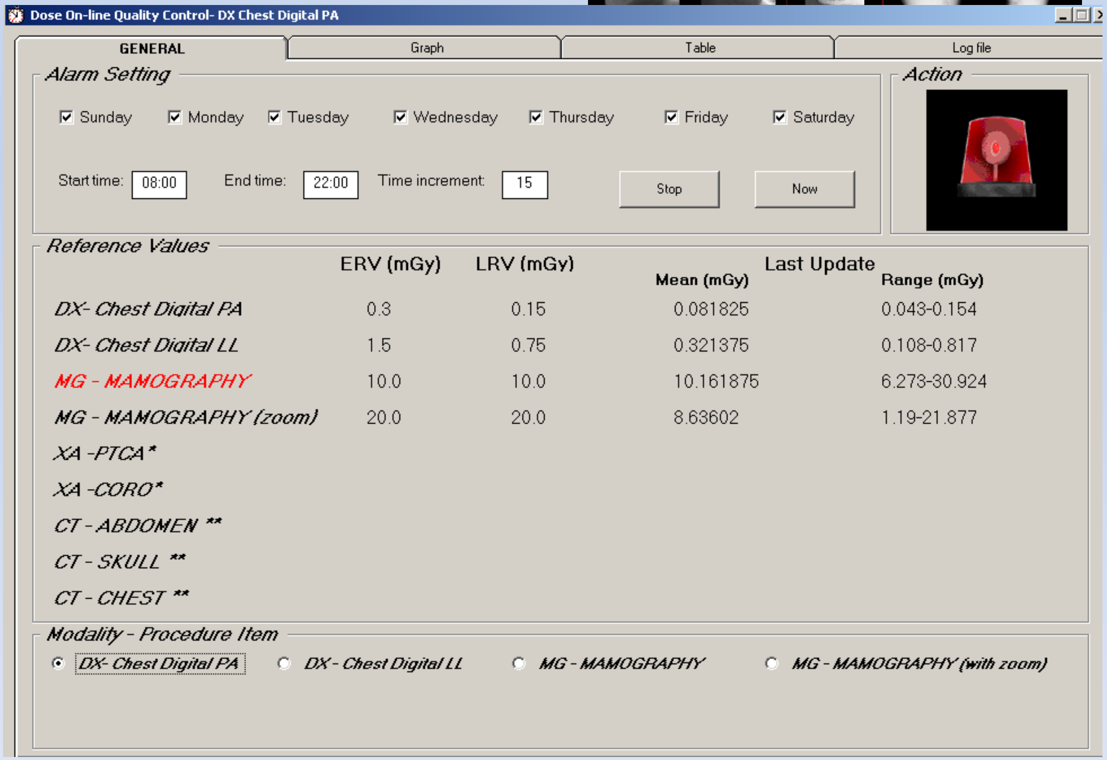
QC on line I (year 2000)

- CR DICOM header without technical data
- Direct connection to generator to get technical parameters
- Dose calculation
- Patient thickness estimation per examination type
- Comparison with local and international reference values

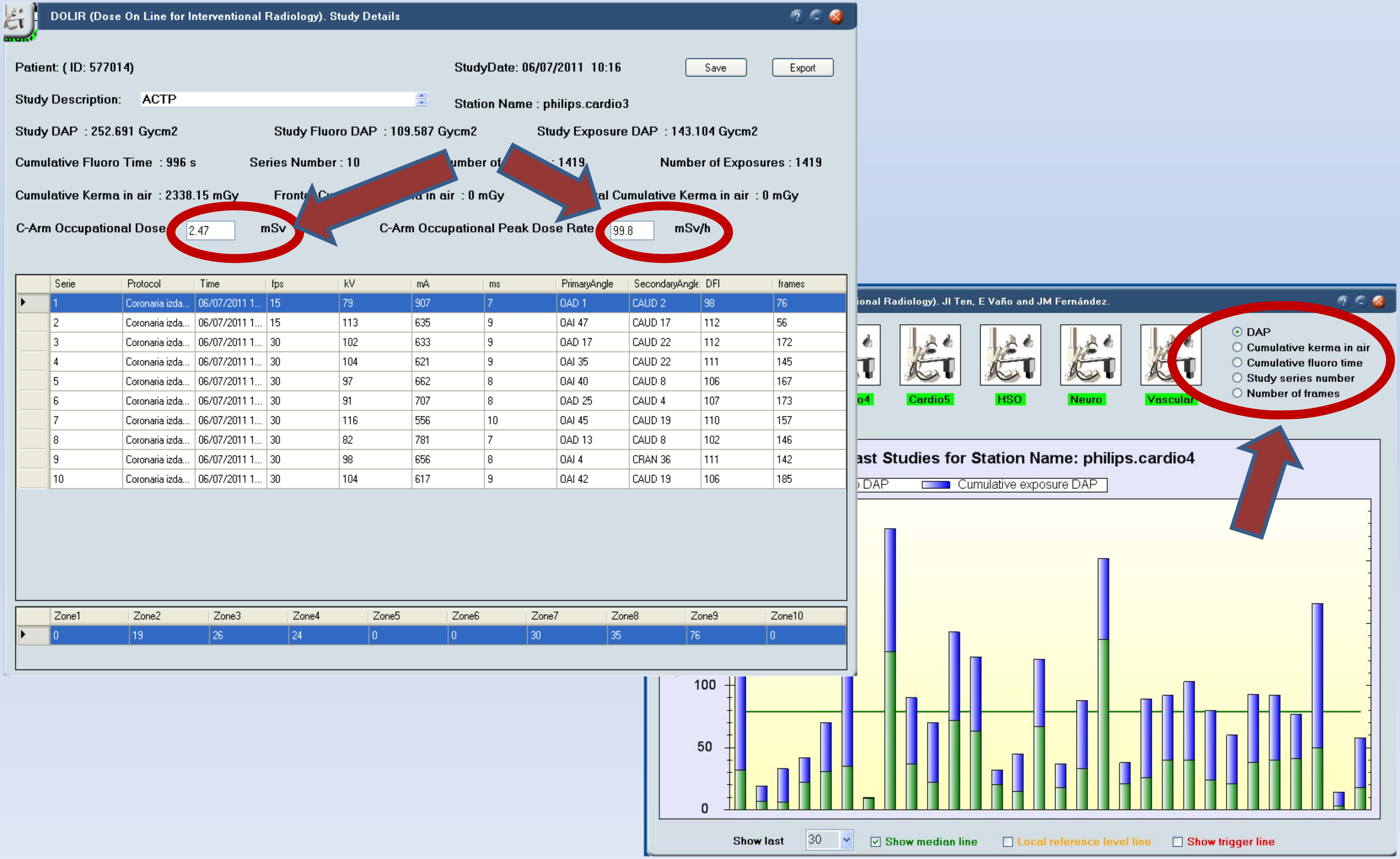


QC on line II (year 2003)

- Designed for flat panel and cardiology.
- Physical link between the clinical image and the radiographic and dose data.
- Easy to audit dose values, radiographic data, image quality related with dose and repetition rate.



QC on line interventional (DOLIR 2008)

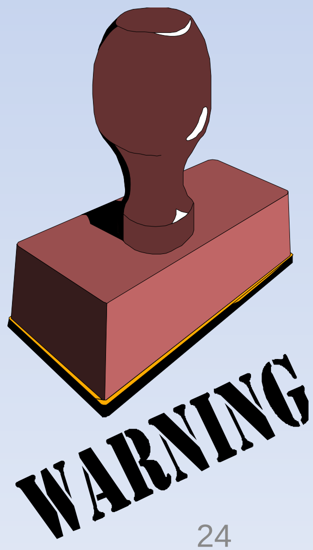


Special relevance of commissioning

- When commissioning digital systems, it should be ensured that imaging capability and radiation dose management are integrated to achieve acceptable clinical imaging using appropriate patient doses.
- Network and connectivities should also be verified.

Special relevance of justification and optimization in DR

- Justification and optimization criteria should be the key components to be considered in the update of a quality assurance programme when a facility converts to digital imaging.
- With digital fluoroscopy systems it is very easy to obtain (and delete) images.
- There may be a tendency to obtain more images than necessary.

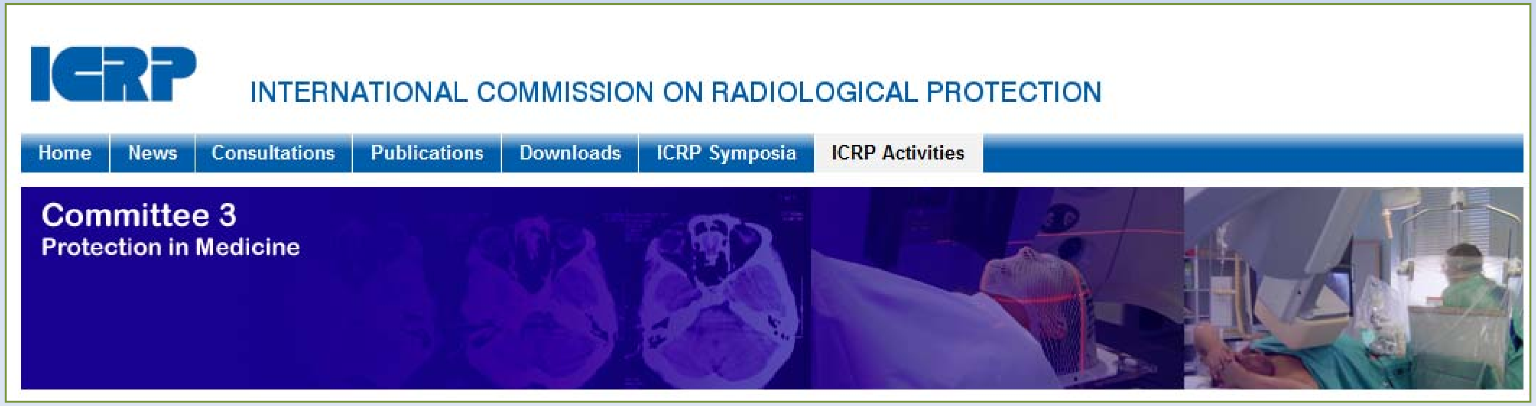


Diagnostic Reference Levels

- Diagnostic Reference Levels (DRLs) introduced by ICRP in 1990 (and complemented in 2001) with a view to identify unusually high levels of patient dose are **especially useful in digital imaging** to determine that the imaging system and the imaging acquisition protocol and processing have been adequately optimized.
- ICRP recommends that local diagnostic reference levels **should be reviewed when new digital** systems are introduced in an operational facility.
- With digital techniques, the exploitation of **the full individual patient dose distributions** is available to help with optimization in addition to DRLs.

ICRP created in 2012, a Working Party to revisit DRLs for diagnostic and interventional imaging

- **Need to expand the application of the DRL concept** to interventional procedures, nuclear medicine procedures, and other procedures that use more than one imaging modality.
- **Use not only a percentile (e.g., 75 th) of the patient dose distributions** but the full distribution, to help in optimization.
- Based on the initial discussions, C3 will consider setting up a Task Group at its next meeting.



DRL and Optimization. Topics for discusssion

1. The use of **phantoms versus patient dose values** needs some refinement (consider **protocols and operator impact**).
2. Link between **DRLs and image quality or diagnostic information (including post-processing) for different clinical tasks**.
3. Standardization and consensus on **the levels of complexity** for some common procedures and the impact on DRLs.
4. Possibility of **deriving trigger (alarm) levels** from DRLs to investigate individual cases of high dose values.
5. Exploitation of the **full individual patient dose distributions** in addition to DRLs, to help with optimization.
6. Balancing the **relevance of several dose related quantities** used to set DRLs (e.g. KAP, cumulative Air Kerma, number of cine or DSA images, fluoroscopy time, rotational, CBCT, etc).
7. Recommended **periodicity to update DRLs**, and factors to be considered to establish such periodicity.

San Carlos University Hospital Madrid