Digital Radiology: opportunities for online quality control and dosimetry

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1. Images are received
2. DICOM header information is extracted
3. COMPARISON with reference values
4. ALARMS are displayed
On-line patient dosimetry and procedure audit system in digital radiology

- The auditing system is not restricted to doses only.
- Data on relevant parameters and details on the imaging procedure is also provided.
- A link with images and demographic data has been implemented.

- X-ray units equipping flat panel,
- Computed radiography (CR),
- Interventional radiology (IR) facilities with image intensifier or dynamic flat panels.
- All working under DICOM standard.
On-line patient dosimetry and procedure audit system in digital radiology

- The system has been implemented in two GE X-ray units equipping flat panels and several X-ray units using CR systems from AGFA.
- Also, three dedicated X-ray interventional cardiology rooms equipped with Philips Integris models.

Patient dosimetry audit is performed by comparing mean values of entrance dose or dose-area product with diagnostic reference levels (DRL’s).
- Individual values are also audited and alarms are triggered when doses are substantially higher than the DRL’s.
On line quality control

- When alarm conditions are triggered investigation of the causes or decision on patient clinical follow up for skin injuries, after interventional procedures, can be adopted.

1. To evaluate patient doses
2. To compare with references
3. To analyse anomalous data
4a. To introduce corrective actions
4b. To go on with surveillance
On line quality control

- Technical parameters (kV, mAs, radiation field size, etc) and details of operational practice (compression strength in mammography, proper automatic exposure control sensor choice, etc) are audited, using data available in the DICOM header.

- For CR, the exposure dose index and post processing parameters are audited.
- For IR, the number of images per series, the total number of series and the total number of images per procedure are also susceptible of generating alarms.
Interventional radiology ...

- For IR, also, the dose-area product and the cumulative dose at the interventional reference point can be audited if present at the DICOM header.
- It will also be implemented alarm conditions when a high concentration of radiation fields occurs during interventional procedures.

QC on line – updates ...

- The system for QC on line is working at the San Carlos University Hospital in Madrid from 1999. After several upgrades it is now a valid platform for practically all digital modalities.
- The first version for CR systems was initiated using the Philips digital generators and the Philips “PDO” product (patient data organizer).
DICOM HEADER
(with important information to audit patient doses and procedure)

Relevant DICOM tags GE Chest flat panel

- (0008,0020) : Study Date : 27/01/03
- (0008,0030) : Study Time : 10:31:12
- (0008,0033) : Image Time : 10:32:43
- (0010,0020) : Patient ID : 795607
- (0010,0040) : Patient’s Sex : F
- (0010,1010) : Patient’s Age : 085Y
- (0010,1011) : Patient’s Age (years) : 85
- (0018,0015) : Body Part Examined : Chest
- (0018,0060) : KVP : 125
- (0018,1150) : Exposure Time : 5
- (0018,1151) : X-ray Tube Current : 250
- (0018,115E) : Image Area Dose Product : 0.83557
- (0018,1190) : Focal Spot(s) : 0.6
- (0018,1405) : Relative X-ray Exposure : 61
- (0018,7060) : Exposure Control Mode : AUTOMATIC
- (0018,7062) : Exposure Control Mode Descript : AUTO
- (0028,0010) : Rows : 2022
- (0028,0011) : Columns : 2022
- (0028,0010) : Bits Allocated : 16
- (0028,0011) : Bits Stored : 14

Aplicable to CR. Without link with demographic data neither images.
Using Philips PDO.
Version II: 2001-2002
Aplicable to “flat panel” systems. Link with demographic data and images.

Versión III: 2002-2003
Including information about procedures, selectable alarms and calibration factors.
Versión IV: 2003 … Including on screen graphs and automatic archive of images with problems.
What are the audited parameters?

1. Patient entrance dose (entrance air kerma).
2. Dose area product (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).
10. Image quality (basic evaluation).

Usefulness of the system …

• It is possible to audit quality parameters on line:
  • Visualization of **images** individually or in mosaic format.
  • Alarms are detected, archived and written in the **DICOM header** of the images storing a duplicate for ulterior analysis.
  • **Audit in real time** is done for a great number of parameters related with patient dose and image quality.
Usefulness of the system ...

- The system gives the possibility to implement corrective actions in real time ...
  - If mean dose values are higher than reference values.
  - If the X-ray system is not used in the appropriate way (e.g. incorrect radiographic technique, lack of compression in mammography, etc).
  - If the X-ray system has some failure (e.g. in the automatic exposure control).

Usefulness of the system ...

- With a QC on line ... digital radiology is more cost-effective.
  - It is possible to reduce patient doses.
  - It helps to reduce retakes.
  - It helps to detect procedures with an excessive number of images.
  - It helps to improve the work flow.
Some examples of the working system

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Wed 5Feb03 audit: Alarm in mammography ....

Wed 5Feb03 audit: Alarm in mammography ....look at the graph of doses ...

Correspondence: <eliseov@med.ucm.es>. Leuven, Belgium, 25th – 27th March 2004
Wed 5Feb03 audit: Alarm in mammography ... look at the images ...

Wed 5Feb03 audit: Alarm in mammography ... look at the images ...

patient arm on the beam!! (32 mGy)
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January 03: Audit ... This image has been done at 75 kV!!!
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QC on line alarm in cardiology: high number of series and high number of frames
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8. Exposure index and postprocessing parameters (for CR).
10. **Image quality (basic evaluation).**
13 January 03: Example the lack of information to the patient ....

Image compression ... to increase network transmission speed ... but reducing quality ...
Different compression levels

- Chest CR without compression 22.3 MB
  - Matrix: 3062 (horizontal)x 3730 (vertical); Bits stored : 12
  - Transmission of 10 images in a network of 100Mb/s, requires typically 25 s.

- Chest CR with compression QF 50;  3.0 MB
  - Transmission of 10 images in a network of 100Mb/s, requires typically 4 s.

- Chest CR with compression QF 10;  0.8 MB
  - Transmission of 10 images in a network of 100Mb/s, requires typically 1.6 s

- Chest CR with compression QF 1;     64 kB
  - Transmission of 10 images in a network of 100Mb/s, requires typically < 1 s
Compression factor: 82
International Workshop on Optimisation of Dose and Performance in Interventional and Digital Imaging.

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Software requirements

Hardware:
• Conventional advanced PC

Software:
• Windows 2000/XP
• Microsoft SQL Desktop Engine ó SQL Server
• Office 2000/XP

Operational framework

Installation with PACS:
• IMPAX (AGFA GEVAERT)
• INTURIS SUITE (PHILIPS)

Installation with DICOM systems from:
• GE
• Philips
• Agfa
Transportability of the system ...

What is needed?

• PACS availability (but not strictly necessary).
• To know the “DICOM conformance” details of the modalities to be integrated.

Specially relevant!!

• To know the parameters to be audited and their trigger levels.
• To know the details of the tags in the “DICOM conformance” allowing to obtain the values of such parameters (including private fields).
• To establish a periodic calibration and verification of the audited parameters (DICOM header values not always correspond to the real values).