

# Improving patient dose management using DICOM header information. The European SENTINEL experience.

E. Vano, R. Padovani, V. Neofotistou, V. Tsapaki, S. Kottou, J.I. Ten, J.M. Fernandez and K. Faulkner

## I. INTRODUCTION

Fluoroscopically guided interventional procedures can deliver substantial patient doses. Optimizing patient care includes balancing radiation and other risks of a procedure against the expected benefits. Optimization includes the decision to perform the procedure, ongoing benefit-risk analysis during the procedure, and post-procedure patient management.

New digital radiology X-ray systems working under DICOM (Digital Imaging and Communications in Medicine) standards produce images with relevant technical and dosimetric information contained in their DICOM header file. This information allows the audit of clinical protocols and the improvement of patient dose management especially during fluoroscopically guided procedures in radiology and cardiology.

Interventional fluoroscopes complying with the International Electrotechnical Commission IEC 60601-2-43 [1] provide means for monitoring the Dose Area Product (DAP) and the cumulative dose at a reference point (could be considered as the point on the skin where the X-ray beam enters into the patient). This information is displayed continuously on the monitor for operator's information during the procedure. The Food and Drug Administration (FDA) in USA has proposed that similar displays be available on all fluoroscopes [2]. No standards exist so far for estimating or displaying radiation dose distribution on patient's skin produced by a moving X-ray beam [3]. Skin dose mapping means have been investigated [4], [5].

This study was partially funded under the European Commission 6th Framework Programme SENTINEL Coordination Action "Safety and Efficacy for New Techniques and Imaging using New Equipment to Support European Legislation (FP6 – 012909)".

E. Vano, J.M. Fernandez are with Medical Physics, San Carlos Hospital. Radiology Department, Complutense University. Madrid, Spain.

R. Padovani is with Santa Maria della Misericordia Hospital. Udine, Italy.

V. Neofotistou is with Department of Medical Physics, Athens General Hospital "G. Gennimatas". Athens, Greece.

V. Tsapaki is with Medical Physics Department, Konstantopoulou Agia Olga Hospital. Athens, Greece.

S. Kottou is with Medical Physics Department, Medical School, Athens University. Athens, Greece.

J.I. Ten is with Diagnostic Radiology Service, San Carlos University Hospital. Madrid, Spain.

K. Faulkner is with Quality Assurance Reference Centre. Silverlink Business Park. Wallsend NE28 9ND, United Kingdom.

Modern fluoroscopes produce digital images, which are archived in DICOM format. A great deal of technical information describing the acquisition of the images and other details of the clinical protocol can be found in the DICOM headers that accompany the images. Some information is stored as 'public' data elements thus any appropriate DICOM reader can have access to them. However, some other information is stored in 'private fields' and in this case manufacturer's cooperation is needed to retrieve them if the full information is not included in the DICOM conformance statement document. Moreover, the format and data elements may vary from manufacturer to manufacturer.

The present DICOM public header may provide dose information related to individual images or series and may or may not include the fluoroscopy runs. This dose information associated with an image/series can be lost if the image/series is not archived.

A cooperative programme between IEC and the DICOM Committee is currently defining the dosimetric elements that need to be stored for every examination performed using X-rays as well as the organization of the storage format within public fields in DICOM.

The DICOM header of archived images (or fluoroscopy runs) contains very useful information for patient dosimetry and quality control.

It is a priority for the radiology industry to enrich and standardise this information and to make it easily available to the users. The capability to transfer this information to a database for further utilisation should also be part of the goal.

The evaluation carried out during the European Coordination Action SENTINEL (Safety and Efficacy for New Techniques and Imaging using New Equipment to Support European Legislation) is described and benefits for the computerized patient record and healthcare networks are highlighted.

## II. METHODS AND MATERIALS

Several radiology and cardiology images produced by modern X-ray systems from different manufacturers have been analysed looking the contents of the DICOM header in the individual images, cine series, DSA (digital subtraction angiography) series and fluoroscopy runs.

Computed radiography (CR), flat panel detectors (FD) for radiography and fluoroscopy systems equipped with image intensifier and dynamic FD have been also included in the survey (figures 1 and 2).

(0008,0020) : Study Date	: 04/12/2003
(0008,0022) : Acquisition Date	: 04/12/2003
(0008,0060) : Modality	: CR
(0008,0070) : Manufacturer	: AGFA
(0008,0080) : Institution Name	: HCSC
(0008,1010) : Station Name	: ADCC2
(0008,103E) : Series Description	: lumbar AP
(0010,1010) : Patient's Age	: 020Y
(0018,0015) : Body Part Examined	: LSPINE
(0018,1004) : Plate ID	: U13-35
(0018,1401) : Acquisition Device Processing	: 60025la712Ra
(0018,1403) : Cassette Size	: 35CMX43CM
(0018,1404) : Exposures on Plate	: 342
(0018,5101) : View Position	: AP
(0018,6000) : Sensitivity	: 4.00000000E+02
(0019,1010) : Image processing parameters	:
MENU=60025 CC=0 MC=3.00 EC=0.00 LR=2.00 NR=4.00	
(0019,1013) : Sensitometry name	: NK5
(0019,1015) : Dose monitoring list	: 1.54
(0020,0013) : Image Number	: 1
(0020,1002) : Images in Acquisition	: 1
(0028,0010) : Rows	: 3730
(0028,0011) : Columns	: 3062
(0028,0100) : Bits Allocated	: 16
(0028,0101) : Bits Stored	: 12
(0028,0102) : High Bit	: 11

Fig. 1. Example of some of the DICOM tags in the header of AGFA CR

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
(0018,0015) : Body Part Examined	:
(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: AEC_left_and_right_cells	
(0028,0010) : Rows	: 2022
(0028,0011) : Columns	: 2022
(0028,0100) : Bits Allocated	: 16
(0028,0101) : Bits Stored	: 14

Fig. 2. Example of some of the DICOM tags in the header of GE flat panel

There is data currently available in the DICOM headers of the cine-angiographic series that describes the imaging geometry (e.g. source-image-receptor distance, beam angulation, image-receptor field-of-view, collimation, etc) and radiographic factors (e.g. kVp, mAs, number of frames, etc) associated with that series. These factors can be combined with the X-ray tube

output calibration data to calculate patient's skin-dose distribution.

Bespoke software produced by the SENTINEL consortium [6] allows the extraction of the information contained in the DICOM header of the images and transfers it to a database. Identification of the different DICOM tags and evaluation of their accuracy permit the use of this information for the audit of clinical protocols and patient doses.

### III. RESULTS

It has been discovered that the full DICOM header information is not easily obtained from all the software packages available to visualize clinical images.

Important information (useful for dosimetric purposes) is still contained in private tags. The format and meaning of these fields is not easily available and not well defined in the DICOM conformance statement documents.

There are at present, important differences between the producers of the X-ray systems regarding the content of dosimetric information in the DICOM header. Moreover, the units of some of the dosimetric quantities vary between different X-ray manufacturers.

The calibration factors for some of these quantities must be verified and taken into account by the local medical physicists.

Hopefully, the work in progress between IEC and DICOM to produce a standard in this area will improve the situation in the future.

The DICOM "MPPS" (Modality Performed Procedure Step) [7] is an interesting option now available in some systems. The transmitted MPPS files contain basic dosimetric information but many Radiological Information Systems (RIS) still do not accept these files.

The dose reports produced by most of the interventional X-ray systems are useful documents to help in the audit of patient doses and procedures. Their information content and format should be standardized. These reports should be available in an appropriate electronic format.

Preliminary experiences already exist in some European hospitals (some of them involved in the SENTINEL consortium) on the use of DICOM header to audit patient doses and procedures protocols.

### III. CONCLUSION

The efforts of the radiology industry in standardisation of the DICOM header and the cooperation between the DICOM and IEC committees should soon allow the complete audit

of x-ray procedures and patient dose. Automatic records and comparison with reference values could be used to trigger alarms if one of the parameters monitored was out of tolerances. It is anticipated that this approach will improve clinical practice.

#### REFERENCES

- [1] Medical electrical equipment, Part 2-43: Particular requirements for the safety of X-ray equipment for interventional procedures, *IEC 60601-2-43*, First edition 2000-06, International Electrotechnical Commission, Geneva, Switzerland, [www.iec.ch](http://www.iec.ch).
- [2] Food and Drug Administration, Proposed Rule: Performance Standards for X-ray Systems and their Major Components. *Federal Register*, vol. 67, no. 237, pp. 76056-76094, 2002.
- [3] E. Vano, L. Gonzalez, J. I. Ten, J. M. Fernandez, E. Guibelalde and C. Macaya, "Skin dose and dose-area product values for interventional cardiology procedures", *Br. J. Radiol.*, vol. 74, pp. 48-55, 2001.
- [4] A. Den Boer, P. J. de Feijter, P. W. Serruys and J. R. T. C. Roelandt, "Real-time quantification and display of skin radiation during coronary angiography and intervention", *Circulation*, vol. 104, pp. 1779-1784, 2001.
- [5] D. L. Miller, S. Balter, P. E. Cole, H. T. Lu, A. Berenstein, R. Albert, B. A. Schueler, J. D. Georgia, P. T. Noonan, E. J. Russell, T. W. Malisch, R. L. Vogelzang, M. Geisinger, J. F. Cardella, J. S. George, G. L. 3rd Miller, J. Anderson, "Radiation doses in interventional radiology: The RAD-IR study Part II. Skin dose", *J Vasc Interv Radiol.*, vol. 14, pp. 977-990, 2003.
- [6] <http://www.dimond3.org/> (last access 05/07/06).
- [7] P. Mildemberger, M. Eichelberg and E. Martin, "Introduction to the DICOM standard", *Eur. Radiol.*, vol. 12, no. 4, pp. 920-927, 2002.