CT RADIATION DOSE REPORT FROM DICOM

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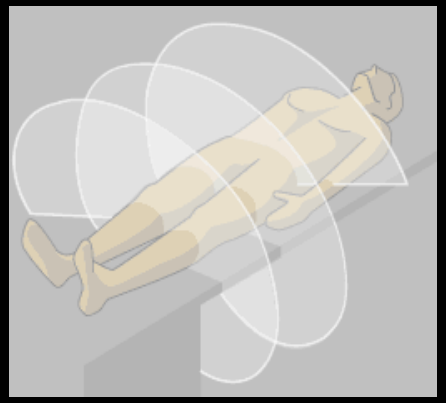
CT

Patient goes in . . .

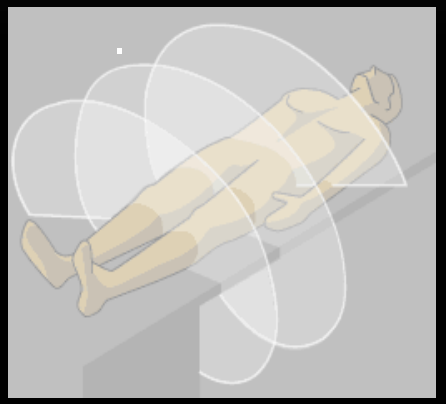


Big

Black

Box

Patient comes out . .



Radiology report

Hx none provided (as usual).

Technique: CT abdomen and left knee

Findings: Kjaekjrht ekrhtkje wejkkjsnf. There is nothing to see on this TC because the history was useless.

Impression: See below

. . . with a report!

CT Radiation Dose Reporting

- California legislation requires CT radiation dose (either CTDIvol or Dose Length Product) be included in every radiology report (Commencing July 1, 2012)
- Effective July 1, 2016, Joint Commission's new diagnostic imaging standards also require documentation of CT dose in patient's EMR and interpretive report

Where CT Dose Is Recorded?

- Dose/protocol page (most common)
- DICOM Header
- Radiation Dose Structured Report (RDSR)

CT Dose Page

Patient Name: Exam no:

Accession Number: May 31 2014

Patient ID: LightSpeed Pro 32

Exam Description: CT BRAIN WO CONTRAST

Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	-	-	-	-
2	Axial	I190.000-I29.530	48.76	807.62	Head 16
			Total Exam DLP:	807.62	

1/1

GE scanner

CT Dose Page

Ward: ED
Physician:
Operator: RED

30-May-2014 16:26

Total mAs 3125

	Scan	kV	mAs / ref.	CTDIvol	DLP	TI	cSL
Patient Position H-SP							
Topogram	1	80				5.3	1.0
Isovue						100 ml	0.0 ml/s
ABD/PEL W/C	2	120	151 / 180	10.59	490	0.5	1.5

Siemens scanner

CT Dose Page

Exam Information
Study ID:
Time: May 31, 2014, 18:05
Total DLP: 672.8 mGy*cm

Dose

#	Description	Scan Mode	mAs	kV	CTDIvol [mGy]	DLP [mGy*cm]	Phantom Type[cm]
1		Surview	1	120	0.17	5.2	16 CM
2		Axial	N/A	120	45.60	667.6	16 CM

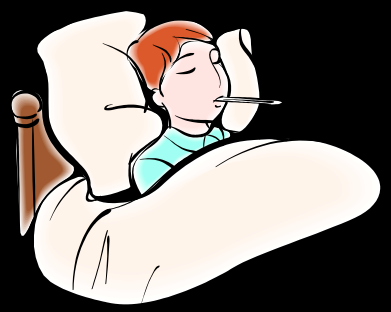
Philips scanner

DICOM Standards

- Digital Imaging and Communication in Medicine (DICOM) is a set of standards developed by the American College of Radiology (ACR) and the National Electrical Manufacturer's Association (NEMA)
- The aim of DICOM standards is to achieve a high level of compatibility among imaging systems and other information systems in healthcare environments worldwide.

DICOM in a Nutshell

- DICOM views real-world data, such as patients, studies, and medical devices as objects with attributes.
- The definitions of these objects are standardized by Information Object Definitions (IOD)



=

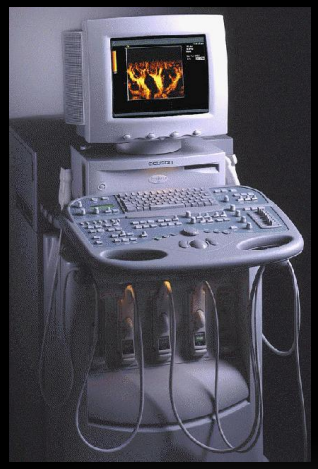
Name	Eric Smith
ID	1234567
DOB	1968 11 11
Weight	74
Sex	M

} Patient IOD (Information object Definition)

DICOM in a Nutshell

- All DICOM attributes are formatted according to 27 Value Representation (VR) types
- Application Entities (AEs): DICOM devices and software
- AEs provide service to each other

CT



U/S

Reading station

Digital Archive server and software

DICOM in a Nutshell

- In DICOM, Service-Object Pairs (SOP) associate each service type with the data (IODs) that they process
- DICOM calls the service requestors Service Class Users (SCUs) and the service providers Service Class Providers (SCPs)
- The imaging device manufacturer's *DICOM conformance statement* is the important document to learn the details and extend of DICOM services the device can provide.

Types of DICOM Services

- DICOM storage
  - CT image storage SOP class
- DICOM print
  - Basic grayscale print management SOP class (SCU only)
- Query / Retrieve
  - Query a DICOM device for a list of studies or patients, then retrieve them
- Worklist Management
  - Download a list of “scheduled procedures” to the modality from the Radiology Information System (RIS) through a worklist management provider
- Modality Performed Procedure Step (MPPS)
  - Modality tells RIS that the procedure has been performed

DICOM Attribute and Tag

- In DICOM, each attribute of an information object has a tag that uniquely identifies itself.
- The DICOM tag is comprised of two short numbers (in hexadecimal format) called Group and Element.
- DICOM attributes that are related to each other sometimes share the same group.
  - X-ray tube current (0018, 9930), kVp (0018, 0060) and exposure time (0018, 1030)

DICOM Image Attributes with Tags for CT Acquisition and Dose (Group 0018)

Tube Voltage	(0018, 0060)	tube's kilovoltage peak value
Tube Current	(0018, 9330)	tube current in mA
Revolution Time in s	(0018, 9305)	The time in seconds of a complete revolution of the source around the gantry orbit
Exposure Time in ms	(0018, 9328)	Duration of exposure fr this frame in milliseconds.
Exposure in mAs	(0018, 9332)	The exposure expressed in milliampere seconds (mAs=mA*revolution time in seconds)
Total Collimation width	(0018, 9307)	The width of the total collimation (in mm) over the area of active x-ray detection.
Single Collimation width	(0018, 9306)	The width of the single row of acquired data (in mm). Note: adjacent physical detector rows may have been combined to form a single effective acquisition row.
CTDIvol	(0018, 9345)	Volume CT Dose Index averaged at specific slice location
CTDI Phantom Type Code Sequence	(0018, 9323)	The type of phantom used for CTDI measurement
Data collection diameter	(0018, 0090)	The diameter in mm of the region over which data were collected.
Spiral Pitch Factor	(0018, 9311)	Ratio of the Table Feed per Rotation to the total collimation
Table Feed per rotation	(0018, 9311)	Motion of the table (in mm) during a complete revolution of the source around the gantry orbit
Exposure Modulation type	(0018, 9323)	A label describing the type of exposure modulation
Scan Length	(0018, 1302)	Size of the imaged area in the direction of scanning motion, in mm

DICOM Tag

- As a convention, DICOM tags with even group numbers are reserved for standard use.
- All old group numbers are reserved for private use, or “private tag”.
- Dose Length Product (DLP) doesn’t have a standard tag assigned. Therefore, it is treated as a private tag.
- Vendor’s *DICOM Conformance Statement* may be able to provide the “private” tag number for DLP. Such as Philips uses the private tag (00E1,1021) for DLP.

Extracting CT Dose from Dose Page or DICOM Header

- For CT scanners with only dose page, one typically uses Optical Character Recognition (OCR) software to extract numbers representing CTDIvol or DLP.
- For all “newer” scanners, CT vendors have adopted DICOM standards and the radiation dose related attributes at the series and image level. Dose values can be extracted electronically from DICOM attributes.
- Most commercially available software uses both approaches for hospitals with mixed generation of scanners.

Limitations with OCR and DICOM Headers

- OCR software is sensitive to the resolution and/or contrast (ww and wl settings) of the dose page.
- Change to the character location may also impact the accuracy of OCR.
- Image-based DICOM header may have duplicated dose value if the image is “derived” from the original, i.e., reconstructed with different kernel or thickness.
- Some radiation exposure events may not be captured if the images resulting from these events are not reconstructed or forwarded from the scanner.

Which one is not part of the services DICOM provides?

20%	1. Storage
20%	2. Query/retrieve
20%	3. Worklist Management
20%	4. Image Segmentation
20%	5. Modality Performed Procedure Steps

Which one is not part of the services DICOM provides?

1. Storage
2. Query/retrieve
3. Worklist Management
4. Image Segmentation
5. Modality Performed Procedure Steps

Answer is 4. DICOM provides storage, query/retrieve, Worklist Management, and MPPS, but not Image Segmentation.

Reference: Oleg S. Pianykh, "Digital Imaging and Communications in Medicine: A practical Introduction and Survival Guide". 2nd Edition.

Radiation Dose Structured Report (RDSR)

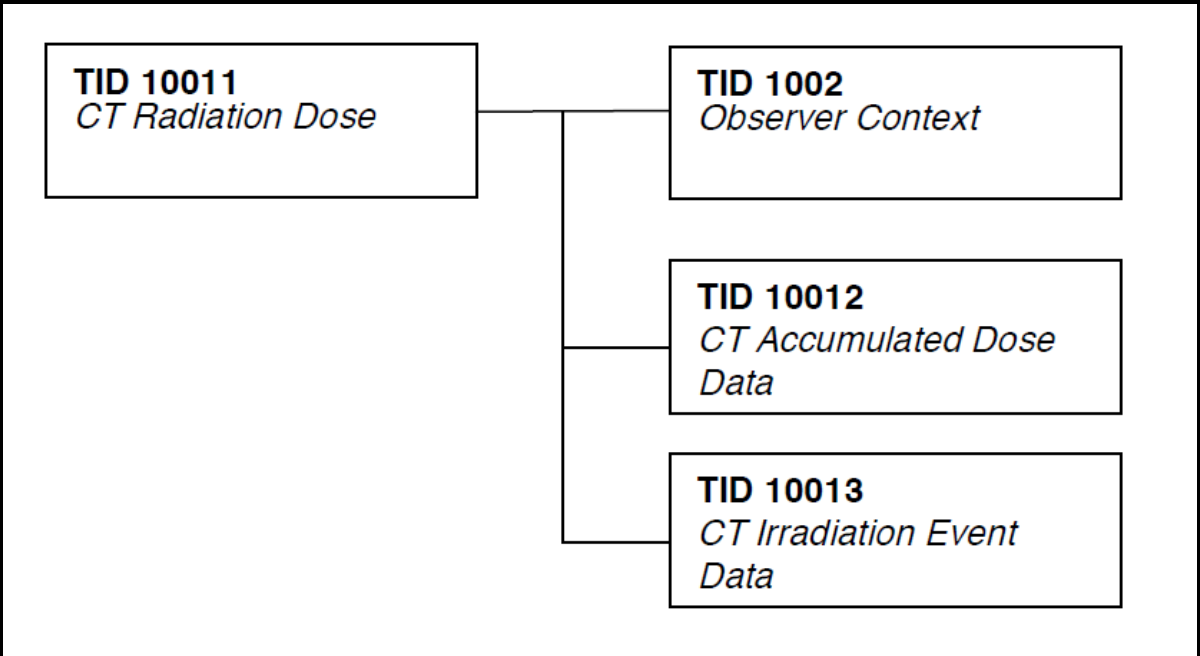
- Compared to the does page and DICOM header, RDSR is a much better way to capture and store radiation exposure related information.
- CT Dose SR is described in detail by DICOM Supplement 127: *CT Radiation Dose Reporting (Dose SR)*
- CT Dose SR is one of four requirements for CT equipment to meet (NEMA-XR-29) by January, 2016, in order to avoid 5% penalties in technical component of reimbursement by Medicare, and penalties rise to 15% in 2017 and thereafter.

What is RDSR?

- RDSR is a member of more extensive DICOM Structured Report (SR) family
- In a simple term, RDSR is a “dose report” with “structure”.
- Here, “structure” means a “content tree”: a large amount of information organized in a tree-like structure.
- For CT, the contents have three parts: 1) the DICOM header; 2) the dose accumulation container; 3) the container holding the information for each irradiation event.

What is a Dose SR Template?

- In CT Dose SR, a Template Identifier (TID) is used to help organize the structure and specify the rules.



CT Radiation Dose SR IOD Template Structure

CT Irradiation Event template (TID10013)

>Acquisition protocol

>Target region

>CT Acquisition type

>Procedure Context

>Irradiation Event UID

>>Exposure Time

>>Scan Length

>>Normal Single Collimation Width

>>Pitch Factor

>>Number of X-ray Sources

>>> Identification of the X-ray Source

>>> KVP

>>> Maximum X-ray Tube Current

>>> X-ray tube current

TID10013 (cont.)

>>> Exposure Time per Rotation

>>> X-ray Filter Aluminum Equivalent

>> Mean CTDIvol

>> $CTDI_{w}$ Phantom Type

>> $CTDI_{free\ air}$ Calculation Factor

>> Mean $CTDI_{free\ air}$

>> DLP

>> Effective Dose

>>> Measurement method

>>>> Effective Dose Conversion Factor

>> CT Dose Check Details

> X-ray Modulation Type

> Person Participant

> Device Participant

RDSR as a Content Tree

A RDSR Viewer

- Most PACS systems rarely have correct SOP class to support CT Dose SR object, therefore, a separate server is needed to receive and parse these encoded RDSR objects into a plain text.
- Every vendor of Dose SR viewer provides reports that differ in appearance and format of dose related information.
- DoseUtility from PixelMed [1] is a useful open source RDSR reader which is Java-based and easy to use.
- A recently published and also free RDSR reader is OpenREM [2]

Procedure reported	Computed Tomography X-Ray
Has Intent	Diagnostic Intent
Observer Type	Device
Device Observer UID	73657
Device Observer Name	PX_CT02RAA031791
Device Observer Manufacturer	SIEMENS
Device Observer Model Name	SOMATOM Definition Flash
Device Observer Serial Number	73657
Device Observer Physical Location during observation	Mayo Clinic PXMH CT02_1665
Start of X-Ray Irradiation	2013-07-24, 09:40:10.010988
End of X-Ray Irradiation	2013-07-24, 09:53:48.372994
Scope of Accumulation	Study
Study Instance UID	1.2.124.113532.172.16.49.225.20130724.91741.2035726

CT Accumulated Dose Data

Total Number of Irradiation Events	8.0 {events}
CT Dose Length Product Total	5,346.0 mGycm

CT Acquisition

Acquisition Protocol	Topogram
Target Region	Head
CT Acquisition Type	Constant Angle Acquisition
Procedure Context	CT without contrast
Irradiation Event UID	1.3.12.2.1107.5.1.4.73657.30000013072404121171200000040
CT Acquisition Parameters	
Exposure Time	4.3 s
Scanning Length	418.0 mm
Nominal Single Collimation Width	0.6 mm
Nominal Total Collimation Width	3.6 mm
Number of X-Ray Sources	1.0 {X-Ray sources}
CT X-Ray Source Parameters	
Identification of the X-Ray Source	A
KVP	100.0 kV
Maximum X-Ray Tube Current	50.0 mA
X-Ray Tube Current	50.0 mA
CT Dose	
Mean CTDIvol	0.1 mGy
CTDIw Phantom Type	IEC Body Dosimetry Phantom
DLP	5.1 mGycm
Comment	Internal technical scan parameters: Organ Characteristic = Head, Body Size = Adult, Body Region = Body, X-ray Modulation Type = NONE
Device Role in Procedure	Irradiating Device
Device Manufacturer	SIEMENS
Device Model Name	SOMATOM Definition Flash
Device Serial Number	73657

CT Acquisition

Acquisition Protocol	Hea
Target Region	Head
CT Acquisition Type	Spiral Acquisition
Procedure Context	CT without contrast
Irradiation Event UID	1.3.12.2.1107.5.1.4.73657.30000
CT Acquisition Parameters	
Exposure Time	4.2 s
Scanning Length	192.0 mm
Nominal Single Collimation Width	0.6 mm
Nominal Total Collimation Width	38.4 mm
Pitch Factor	0.6 {ratio}
Number of X-Ray Sources	1.0 {X-Ray sources}
CT X-Ray Source Parameters	
Identification of the X-Ray Source	A
KVP	120.0 kV
Maximum X-Ray Tube Current	408.0 mA
X-Ray Tube Current	310.0 mA
Exposure Time per Rotation	0.5 s
CT Dose	
Mean CTDIvol	39.5 mGy
CTDIw Phantom Type	IEC Head Dosimetry Phantom
DLP	668.7 mGycm

RDSR Converted to plain text format

Verification of RDSR

- To turn CT RDSR on, check with vendor for the software revision number with RDSR capability
- To verify the Dose SR is correctly generated:
  1) Setup a DICOM SCP node on a computer
  2) Configure the CT scanner to send the CT Dose SR to that node
  3) Using a RDSR reader (such as DoseUtility or OpenREM) to convert the Dose SR into a plain text file
  4) Verify the dose and/or acquisition related parameters are consistent with vendor's DICOM Conformance Statement and the actual dose and acquisition parameters displayed on the scanner

CT Dose SR uses which of the following to organize the structure and specify the rules?

20%	1. DICOM Tag
20%	2. DICOM Attribute
20%	3. Service Object Pairs (SOP)
20%	4. Information Object Definition
20%	5. Templates (TID)

CT Dose SR uses which of the following to organize the structure and specify the rules.

1. DICOM Tag
2. DICOM Attribute
3. Service Object Pairs (SOP)
4. Information Object Definition
5. Templates (TID)

Answer is 5. CT Dose SR uses Template Identifier (TID) to organize the structure and specify the rules.

Reference: DICOM Supplement 127: CT Radiation Dose Reporting (Dose SR).

Current CT Dose SR Is Incomplete

Information is important to patient dose estimate but still missing from RDSR:

1) Parameters for tube current modulation: ref. mAs, Noise Index, Min and Max mA
2) Actual tube current at different view angles.
3) Parameters for iterative reconstruction: IR strength
4) SSDE or WED at various patient longitudinal positions
5) Patient centering, arm positioning and relative anatomical position.

Conclusions

- Dose reporting is an important part of CT quality assurance and patient safety program.
- To better estimate patient specific dose from CT scan, acquisition parameters and patient related information are necessary.
- DICOM CT Radiation Dose SR plays a vital role for both dose reporting and patient specific dose estimate.
- Future enhancement to CT RDSR is also needed.