Informatics Tools for Recording/Tracking Dose

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Standards & Tools



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Learning Objectives

1) DICOM Radiation Dose SR (RDSR) - capturing procedure dose information

2) IHE Radiation Exposure Monitoring Profile (REM)

- **coordinating** the capture and management of RDSR objects applying in a radiology practice.
- 3) "CT dose screens"
 - porting legacy scanner data into RDSR
- 4) MITA CT Dose Check (XR-25)
 - pre-scan dose pop-ups on the CT console
- 5) IHE Integration Statements & DICOM Conformance Statements
 - **<u>specifying</u>** these standards & features when purchasing and integrating radiology systems.

Headers & Screen Shots

Useful but <u>limited</u>

- Missing details
- Not machine-readable
- Duplication issue
- Size issue

44.5	A 190					
21			Ex: Jul 04 2011			
18.5 cm						
			_			
	Patient	Name:			Exa	am no:
to m	Accessi	on Numbe	er:			
C N	Patient	ID:			Discover	y CT750 HD
24	Exam D	escriptior	: CT HALS/THORAX/A	BDOMEN		
			Dose Re	port		
vorate	Series	Туре	Scan Range (mm)	CTDivol (mGy)	DLP (mGy-cm)	Phantom cm
1.375 041.200	1	Scout				
00 L = 40	2	Helical	S15.750-I650.250	5.10	373.00	Body 32
	5	Helical	S188.000-I105.000	5.10	182.72	Body 32
			Total	Exam DLP:	555.72	

DICOM RDSR

Radiation Dose Structured Report Object

	NL	Rel with Parent	∨т	Concept Name	VM	Req Type	Condition	Value Set Constraint
1			CONTAINER	EV (113819, DCM, "CT Acquisition")	1	м		
2	>	CONTAINS	TEXT	EV (125203, DCM, "Acquisition Protocol")	1	U		
3	>	CONTAINS	CODE	EV (123014 , DCM, "Target Region")	1	м		DCID (4030) CT and MR Anatomy Imaged
4	>	CONTAINS	CODE	EV (113820, DCM, "CT Acquisition Type")	1	м		DCID (10013) CT Acquisition Types
5	>	CONTAINS	CODE	EV (G-C32C, SRT, "Procedure Context")	1	U		DCID (10014) Contrast Imaging Technique
6	>	CONTAINS	UIDREF	EV (113769, DCM, "Irradiation Event UID")	1	м		
7	>	CONTAINS	CONTAINER	EV (113822, DCM, "CT Acquisition Parameters")	1	м		
8	>>	CONTAINS	NUM	EV (113824, DCM, "Exposure Time")	1	м		Units = EV (s, UCUM, "s")
9	>>	CONTAINS	INCLUDE	DTID (10014) Scanning Length	1	м		
10	>>	CONTAINS	NUM	EV (113826, DCM, "Nominal Single Collimation Width")	1	м		Units = EV (mm, UCUM, "mm")
11	>>	CONTAINS	NUM	EV (113827, DCM, "Nominal Total Collimation Width")	1	м		Units = EV (mm, UCUM, "mm")
12	>>	CONTAINS	NUM	EV (113828, DCM, "Pitch Factor")	1	MC	IF row 4 equals (P5- 08001, SRT, "Spiral Acquisition") or equals	Units = EV ({ratio}, UCUM, "ratio")

TID 10013 CT IRRADIATION EVENT DATA

Order: Significant

Type: Extensible

DICOM Dose Reports

- "SR Objects" DICOM Structured Reports
 Easily ingested (and regurgitated) by PACS
- Granularity : "Irradiation Event"
 - & Accumulated Dose over Study, Series
- Templates :
 - CT, Projection X-Ray (Mammo, Fluoro, DR/CR)
 - PET/NM (WIP)
- Not addressed: RT









• CT Dose Key Measurements

- DLP, CTDIvol, kVP, mA, sec, ...
- Effective Dose [Optional; Reference estimation method]
- <u>SSDE (CP-1170)</u> [Optional; see AAPM 204]
- Projection X-Ray Dose
 - DAP, Dose@RP, kVP, mA, sec, ...
 - Fluoro Dose, Fluoro Time
 - <u>CR/DR: Exposure Index, Deviation Index</u>
- Mammography Dose
 - AGD, Entrance Exposure@RP, kVP, mA, sec, ...
 - Compression, Half Value Layer

ftp://medical.nema.org/medical/dicom/2011/11_16pu.pdf





Other Details in Dose SR

- Full Patient / Order / Study Details
- Unique ID for each Irradiation Event
- Equipment ID, Ordering Doc, Performing Tech
- Patient Size, Orientation, Anatomy Imaged
- Imaging Geometry
- X-Ray Filtering & Collimation Details
- Anode Target Material
- Calibration, Phantom, Dosimeter, Patient Model

TID 10013				
CT IRRADIATION	EVENT DATA			
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IHE REM Profile

Radiation Exposure Monitoring



IHE in One Slide

- IHE helps vendors implement & test functions that span multiple systems
- Profiles are implementation guides
 - how to use existing standards
 - to address a specific problem scenario
- Connectathons are test events
 - managed testing of Profile implementations
- IHE helps users purchase & integrate multi-system solutions
 - list required IHE Profile support in RFPs





IHE Radiation Exposure Monitoring Profile



Using SR Dose Reports

- Radiation QA
 - Periodically Query / Retrieve Reports from Archive
 - Set policies/standards and flag deviations
 - Set goals for improvement and track progress
 - Implement protocol changes and compare difference in dose
- Regulation
 - E.g. Automatically insert dose metrics into diagnostic reports
- Patient Impact Evaluation
 - e.g. if Patient identified as pregnant post-facto
- Dose Mapping
 - Store data in realtime from Modality to Mapping Workstation

Using SR Dose Reports

National Registries

- Anonymize and submit Dose Reports to Registry
- Compile Population Risk Estimations
- Derive Dose Reference Levels (DRLs)
- Provide Site-Site Comparisons
- Individual Dose Record
 - Collect Dose Reports over time
- Clinical Trials
 - Collect Dose together with Images
 - Demonstrate both improved detection & reduced dose

Legacy Dose Extractors





Legacy Extractor

- What if you can't get REM?
- Extractors create (partial) REM objects
 - Based on OCR of dose screens
 - Based on image header contents
 - Based on MPPS

Date

DLP

Filter

Patient ID

CTDIvol

Patient Weight

- Likely <u>incomplete</u> but still useful
- Allows use of uniform infrastructure (RDSR)
- Current focus: CT, some XA

SSDE

Scan Duration

Example Extractors

Open Source

- "Dose Utility" dclunie.com
 - by David Clunie (PixelMed)
- "Radiance" radiancedose.com
 - by Tessa Cook (Hospital of U of Pennsylvania)
- "GROK" dose-grok.sourceforge.net
 - by Graham Warden (Brigham and Women's Hospital)
- Also
 - ACR Triad Site Server (included in ACR participation)
 - by Mythreyi Chatfield (ACR)
 - ... and a growing number of commercial products

<u>MITA XR-25</u>

CT Dose Check Dose Notification Predicted DLP of 981 mGy-cm Exceeds Threshold ...

MITA CT Dose Check Initiative

- Goals
 - Enhance dose awareness (CTDI/DLP)
 - Help to avoid excessive radiation events
 - Provide data to sites for QA
- MITA has published the standard (XR-25)* Manufacturers worked to ensure
 - Uniformity
 - Speed of implementation
 - Breadth of deployment

* http://www.nema.org/stds/xr25.cfm

Dose Notification

- Pop-up message
 - Notifies technologist that dose <u>for a current scan element</u> will exceed a trigger value
 - Tech may:
 - confirm and proceed, or
 - go back and adjust scan parameters
 - System records audit trail
 - Predicted dose, Notification value, Date/time, diagnostic reason, etc.
- Clinical sites set values that will trigger a notification
 - Can set DLP and/or CTDI_{vol} values for each scan element e.g. head without contrast
 - Defined by the clinical site for their patient population

Dose <u>Alert</u>

Pop-up message

- Alerts technologist *cumulative* dose *for current study* will exceed a trigger value:
 - CTDI_{vol} (summed at each patient location)
 - DLP (summed over the current study)
- Tech may:
 - enter their name, (& a password if configured), confirm and proceed, or
 - go back and adjust scan parameters
- Clinical sites set values that will trigger an alert
 - Can set DLP and/or CTDI_{vol} values
 - System must allow at least one global value
 - System tracks accumulated CTDI_{vol} at each patient location & accumulated DLP
 - System checks predicted accumulated dose indices when protocols are saved & when scans are ready

Default Values

- The FDA has suggested an **<u>alert value for CTDIvol of 1000 mGy</u>**,
- AAPM suggested **notification values**
- <u>http://www.aapm.org/pubs/CTProtocols/</u>
- Can be changed at local site
- Consider behavior modification vs alert fatigue

Table 1: Notification Values recommended by the AAPM Working Group on Standardization of CT Nomenclature and Protocols

CT Scan Region (of each individual scan in an examination)	CTDIvol Notification Value (mGy)
Adult Head	80
Adult Torso	50
Pediatric Head	
<2 years old	50
2 – 5 years old	60
Pediatric Torso <10 years old (16-cm phantom) ^a <10 years old (32-cm phantom) ^b	25 10
Brain Perfusion (examination that repeatedly scans the same anatomic level to measure the flow of contrast media through the anatomy)	600
Cardiac Retrospectively gated (spiral) Prospectively gated (sequential)	150 50

^a As of January 2011, GE, Hitachi and Toshiba scanners use the 16-cm-diameter CTDI phantom as the basis for evaluating dose indices (CTDI_{vol} and DLP) displayed and reported for pediatric body examinations.

^b As of January 2011, Siemens and Philips scanners use the 32-cm-diameter CTDI phantom as the basis for evaluating dose indices (CTDI_{vol} and DLP) displayed and reported for pediatric body examinations.

Audit Trails

- Pop-up Overridden? System must record:
 - Dose Notification
 - Predicted dose, Notification value, Date/time, Diagnostic reason
 - Dose Alert
 - Predicted dose, Alert value, Date/time, Diagnostic reason, Operator name
- RDSR has fields to record all these details
 - May choose to record even if not overridden
- Triggers vs DRLs
 - 75th percentile -> popups on 25% of scans
 - See AAPM guidance



Dose Tracking in Products

- IHE REM
 - Testing: IHE Connectathon (2013: 32 vendors passed REM)
 - <u>http://connectathon-results.ihe.net</u>
 - Product: IHE Integration Statement (2013: 41 products)
 - <u>http://product-registry.ihe.net</u>
- DICOM RDSR
 - Product: DICOM Conformance Statement
- NEMA XR-25
 - Vendor commitment; most new products

<u>Ask</u> for it

- RFPs / Purchase Requirements
 - ... shall support IHE REM as the Acquisition Modality actor ...
 - Ask to see IHE Integration Statements & DICOM Conformance Statements
- Installation / Acceptance
 - Discuss activation / configuration
- Upgrades
 - Some models can be upgraded



Data Collection

- New/recent Modalities
 - IHE REM / DICOM RDSR to capture dose data
- Legacy strategies
 - Dose extractors to generate RDSR data

Analysis

- IHE REM Dose Information Reporter for local analysis
- ACR Dose Registry to compare to benchmarks

Prevention

• CT Dose Check for configurable pre-scan alerts