Automated Recording of Radiation Dose from Modalities

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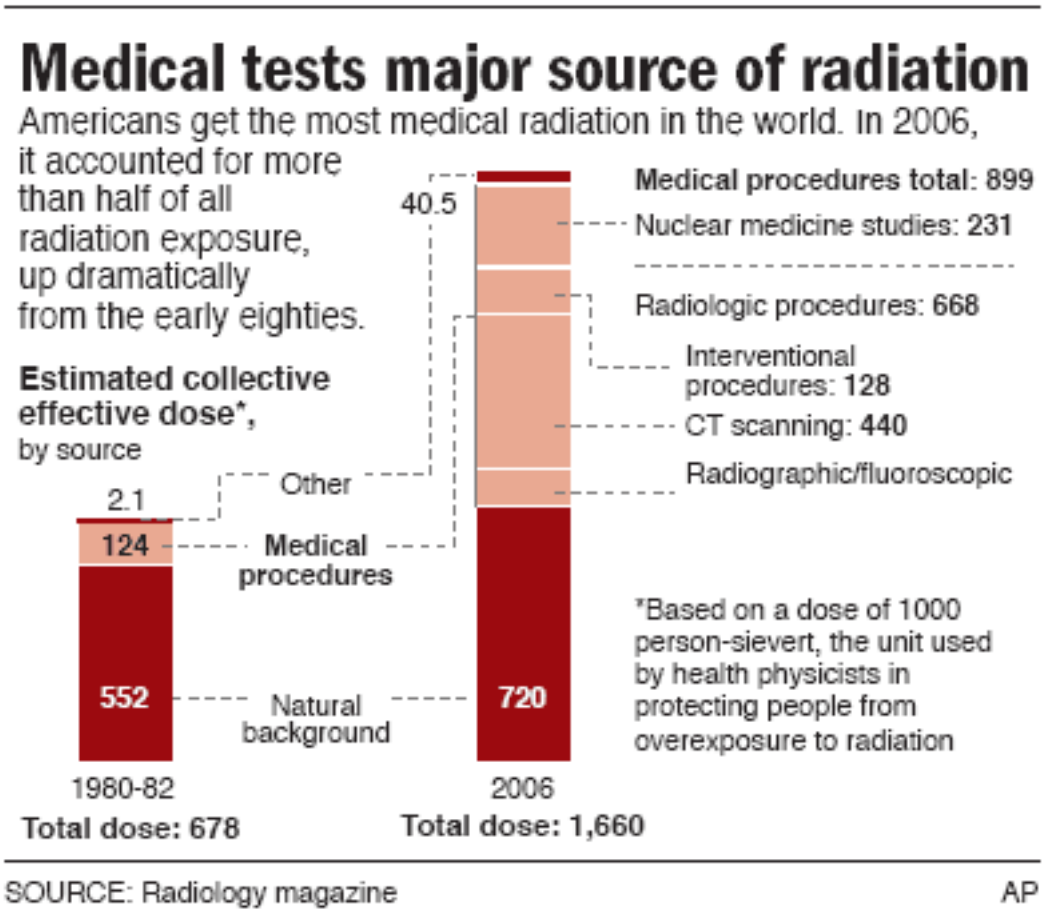
PixelMed Publishing

Scope

- **You already know why (esp. CT)**
- **Are interested in the question of how?**
- **And what?**
- **And perhaps, where ?**

Cedars-Sinai Incident

Popular Press



Dose Information from Modality

- **Multiple possible DICOM sources**

- **Radiation Dose Structured Report**
- **Dose Screen OCR**
- **Reconstructed Image “header”**
- **Modality Performed Procedure Step**

Dose from Modality - RDSR

- **Radiation Dose Structured Report**
  - persistent document-like object
  - store to PACS, RIS, XDS, CD media
  - extensible coded structured content
  - similar to other DICOM “evidence document” structured content like measurements
  - allows transfer and addition of more content
  - contains aggregate and per event exposure
  - contains detailed technique description

DICOM CT RDSR

CT RADIATION DOSE SR IOD TEMPLATES

The templates that comprise the CT Radiation Dose SR are interconnected as in Figure A-12

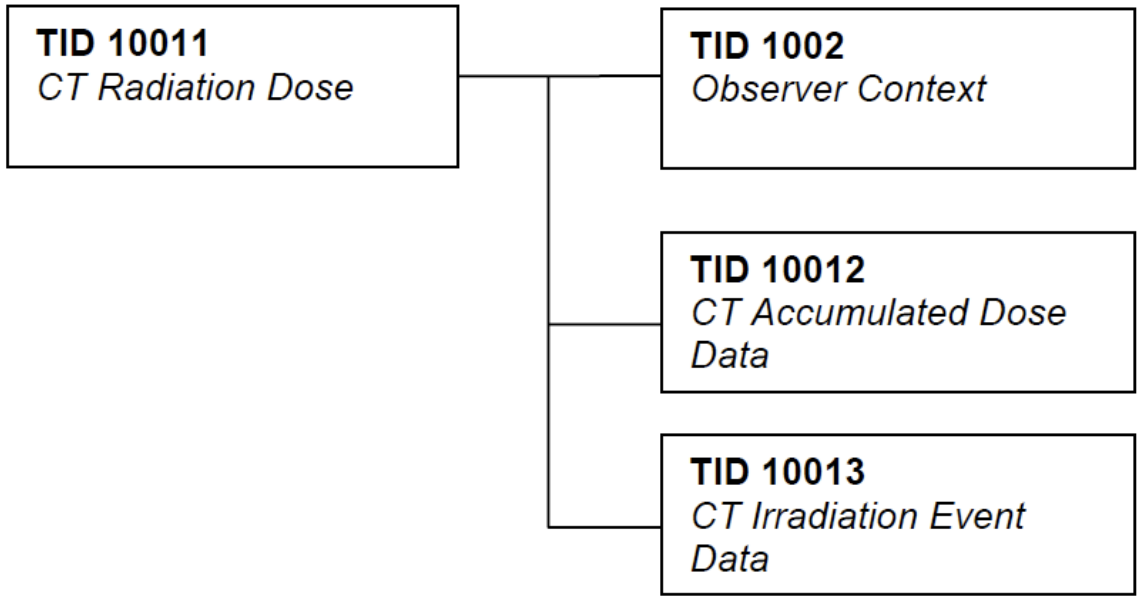


Figure A-12: CT Radiation Dose SR IOD Template Structure

DICOM CT RDSR

- : CONTAINER: X-Ray Radiation Dose Report [SEPARATE] (DCMR,10011)
  - HAS CONCEPT MOD: CODE: Procedure reported = Computed Tomography X-ray
    - HAS CONCEPT MOD: CODE: Has Intent = Diagnostic Intent
  - HAS OBS CONTEXT: CODE: Observer Type = Device
  - HAS OBS CONTEXT: TEXT: Device Observer Name = ilqhfaatc1ws444
  - HAS OBS CONTEXT: TEXT: Device Observer Manufacturer = Philips
  - HAS OBS CONTEXT: TEXT: Device Observer Model Name = Brilliance 64
  - HAS OBS CONTEXT: TEXT: Device Observer Physical Location During Observation = PMSTL
  - HAS OBS CONTEXT: DATETIME: Start of X-ray Irradiation = 20100422162839.030
  - HAS OBS CONTEXT: CODE: Scope of Accumulation = Study
    - HAS PROPERTIES: UIDREF: Study Instance UID = 1.2.840.113704.1.111.6084.1271942101.12
  - CONTAINS: CONTAINER: CT Accumulated Dose Data [SEPARATE]
    - CONTAINS: NUM: Total Number of Irradiation Events = 2 events
    - CONTAINS: NUM: CT Dose Length Product Total = 19.67375 mGycm
  - CONTAINS: CONTAINER: CT Acquisitions [SEPARATE]
  - CONTAINS: CONTAINER: CT Acquisitions [SEPARATE]
    - CONTAINS: CODE: Acquisition Type = Sequenced Acquisition
    - CONTAINS: CODE: Procedure Context = CT without contrast
    - CONTAINS: UIDREF: Irradiation Event UID = 1.2.840.113704.1.111.6084.1271942101.12.2
    - CONTAINS: CONTAINER: CT Acquisition Parameters [SEPARATE]
      - CONTAINS: NUM: Exposure Time = 4254 s
      - CONTAINS: NUM: Scanning Length = 10 mm
      - CONTAINS: NUM: Nominal Single Collimator Width = 0.625 mm
      - CONTAINS: NUM: Nominal Total Collimator Width = 1.25 mm
      - CONTAINS: NUM: Number of X-ray Sources = 1 X-ray sources
      - CONTAINS: CONTAINER: CT X-ray Source Parameters [SEPARATE]
    - CONTAINS: CONTAINER: CT Dose [SEPARATE]
      - CONTAINS: NUM: Mean CTDIvol = 1.3978125 mGy
      - CONTAINS: CODE: CTDIw Phantom Type = IEC Body Dosimetry Phantom
      - CONTAINS: NUM: DLP = 16.77375 mGycm
    - CONTAINS: CODE: Device Role in Procedure = Irradiating Device
      - HAS PROPERTIES: TEXT: Device Manufacturer = Philips
      - HAS PROPERTIES: TEXT: Device Model Name = Brilliance 64
  - CONTAINS: CODE: Source of Dose Information = Automated Data Collection

Dose from Modality - RDSR

- **Radiation Dose Structured Report**
  - general structure common to all modalities
  - specific content for different modalities
  - templates for CT and projection X-Ray
  - fluoroscopy and individual exposures
  - allows a shared infrastructure to manage all ionizing radiation producing diagnostic modalities
  - WIP extension to nuclear medicine & PET

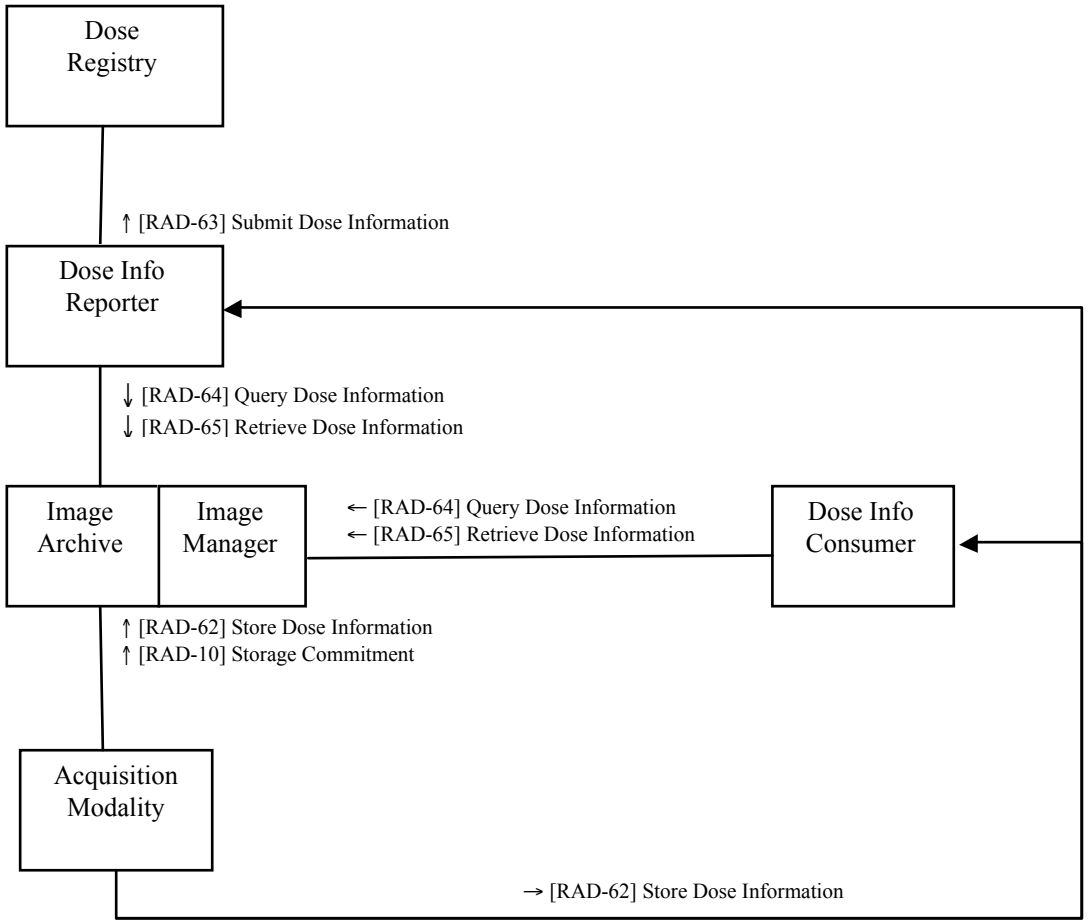
Dose from Modality – CT RDSR

- **CT Radiation Dose Structured Report**
  - irradiation event: uniquely identified
  - scope: event, series, PPS, study
  - accumulated & per-event data
  - phantom exposure required (CTDIvol, DLP)
  - effective dose (mSv) optional (ICRP 60, 103)
  - per-event acquisition parameters (kV,…)
  - standard coded region (anatomy)
  - standard coded CT type (sequenced,spiral,…)

Management – IHE REM

- **Radiation Exposure Monitoring (REM)**
  - Integrating the Healthcare Enterprise (IHE)
  - profile to specify actors & transactions
  - create, store, distribute, report and register
  - Acquisition Modalities create
  - PACS (IM/IA) stores
  - Dose Information Consumer uses
  - Dose Information Reporter sends to Registry

IHE REM Profile



Going Forward

- **Way forward is clear**
  - all new acquisition modality equipment should encode dose in DICOM Radiation Dose Structured Reports (RDSR)
  - all devices should support IHE Radiation Exposure Monitoring (REM) profile, which addresses modality, storage, reporting and registry submission (including PACS)
- **Commitment by vendors to update**
  - “current platform” of modalities only

PRODUCT FAMILY	LIGHTSPEED			
Product	Software	Slices	DICOM DOSE SR	DICOM SC
LightSpeed QX/i		4		
LightSpeed (H-power gantry)		4		
LightSpeed Plus (Compact gantry)		4		
LightSpeed Plus (H-power gantry)		4		
LightSpeed Ultra (Compact gantry)		8		
LightSpeed Ultra (H-power gantry)		8		
LightSpeed 16 (Compact gantry)		16		
LightSpeed 16 (H-power gantry)		16		
LightSpeed Pro 32		32		
LightSpeed RT	07MW11.10	4, 8, 16		
	07BW08.x			
	08BW17.7			
	08BW44.1			
	09HW30.4			
LightSpeed VCT	07MW18.4	64		
	08MW33.2	64		
	09MW08.10	64		
	09MW08.11	64		
	10MW06.5	64		

Dilemma

- **What to do about older scanners**
  - that are not yet updated, and may never be
  - vast majority of global installed base
  - what existing capabilities can be leveraged ?
- **What about new objects in old PACS ?**
  - new modalities may produce RDSR, but …
  - site has no system to view, aggregate, report
- **Even for old images in the archive …**
  - vast collection of reference dose information
  - manual recording is tedious (== expensive)
  - prior data for patients with new studies

Old Scanners

- **Usually no explicit dose information**
  - just technique (kVP, mA, etc.)
  - scanner-specific dosimetry efforts (ImPACT)
  - Garcia et al. 2009
- **Human-readable "dose screens"**
  - CTDIvol and DLP per series & total DLP
  - not (generally) machine-readable
  - can use Optical Character Recognition (OCR)
  - can retrospectively process archive

Key Fields to Extract

Patient Name: Exam no:

Accession Number:

Patient ID: Discovery CT750 HD

Exam Description: CT HALS/THORAX/ABDOMEN

Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	-	-	-	-
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

1/1

Additional Fields to Extract

Patient Name: Exam no:

Accession Number:

Patient ID: Discovery CT750 HD

Exam Description: CT HALS/THORAX/ABDOMEN

Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	-	-	-	-
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	

1/1

Key Fields to Extract

15-Jul-20

Ward:
Physician:
Operator:

Total mAs 15323 | Total DLP 1601 mGy*cm

	Scan	kV	mAs / ref.	CTDIvol mGy	DLP mGy*cm	TI s	cSL mm
Patient Position H-SP							
AP Scout	1	120	36 mA			2.7	0.6
Lateral Scout	2	120	36 mA			2.7	0.6
CCS	3D	120	150	8.49	122	0.2	3.0
Last scan no.	10						
PreMonitoring	11	120	20	0.90	1	0.33	10.0
I.V. Bolus							
Monitoring	12	120	20	9.73	10	0.33	10.0
Last scan no.	22						
Coronary Angio	23D	120	350	91.74	1468	0.33	0.6

Challenges

- **Query and retrieval of dose screens**
- **Extracting sufficient information**
  - matching against actual series
  - information from reconstructed images
  - extracting anatomy and procedure
  - extracting phantom information
  - extracting scanning range
  - establishing scope of accumulation
  - absence of an Irradiation Event UID

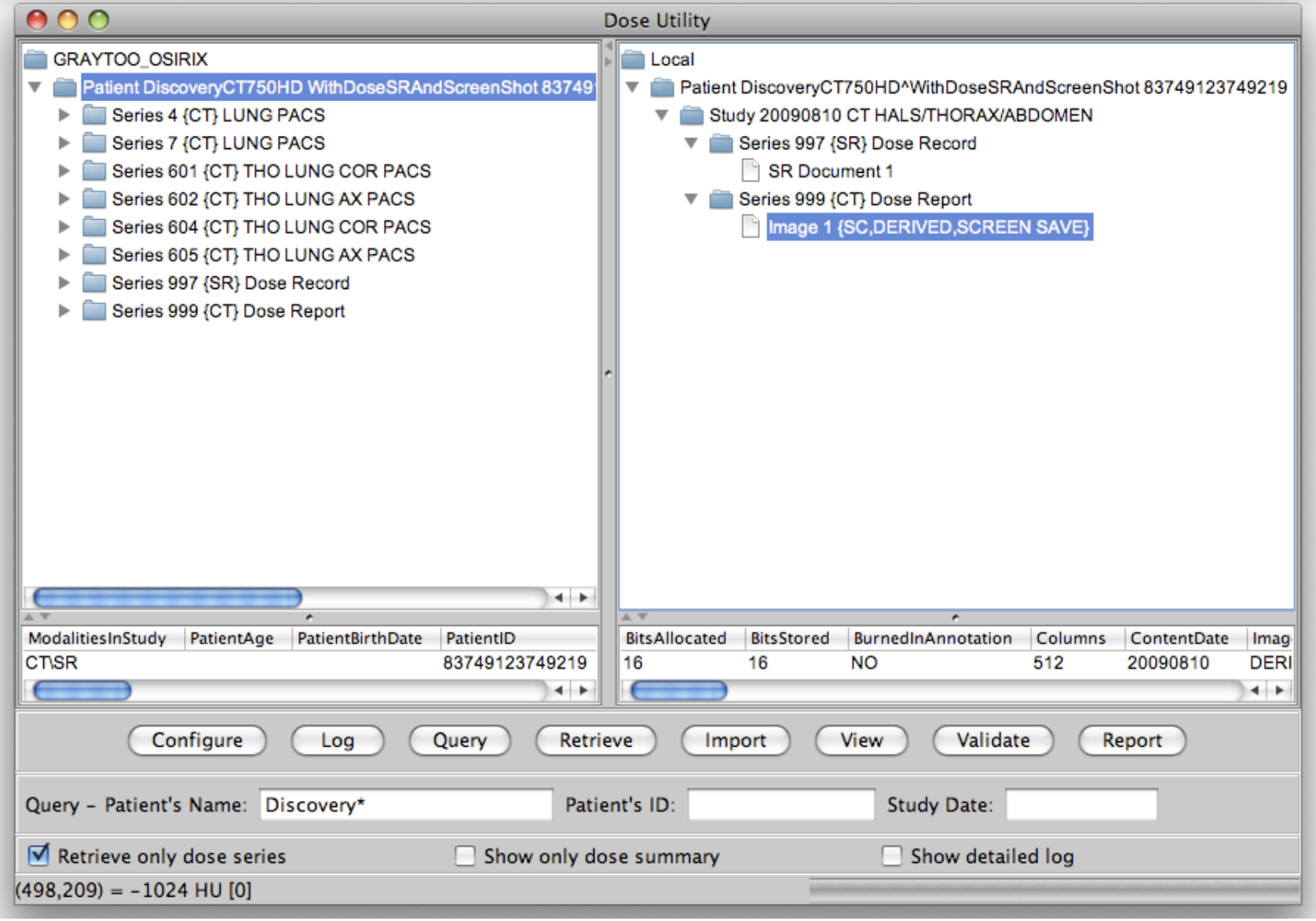
Challenges - Anatomy

- **No coded anatomy information present**
  - legacy scanner consoles
    - no place to select anatomy from standard list
    - not available from Modality Work List (MWL)
    - not copied from protocols
  - so Body Part Examined and Anatomic Region Sequence often empty or absent (or wrong)
- **Attempt to parse plain text**
  - challenging across multiple languages
  - abbreviations and punctuation are problematic
    - C/A/P versus CAP versus Chest/Abdomen/Pelvis

OCR Implementations

- **PixelMed (open source, D. Clunie)**
  - OCR, toolkit, utilities, services, registry submission
  - http://www.pixelmed.com/
- **Radiance (open source, T. Cook UPenn)**
  - dose management system, OCR, effective dose
  - http://radiancedose.com
- **GROK (open source, G. Warden)**
  - anatomy, database, automated size from slices
  - http://dose-grok.sourceforge.net/
- **Valkyrie (G. Shih, Weill-Cornell)**

Dose Utility Prototype



Dose Utility Prototype

Patient Name: Exam no:

Accession Number:

Patient ID: Discovery CT750 HD

Exam Description: CT HALS/THORAX/ABDOMEN

Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	-	-	-	-
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	

1/1

Reporting started

Dose 2009/08/10 13:03:28 CT CT HALS/THORAX/ABDOMEN DLP Total=555.72 mGycm

Series=2 Helical S15.750-I650.250 mm 5.10 mGy 373.00 mGycm BODY32

Series=5 Helical S188.000-I105.000 mm 5.10 mGy 182.72 mGycm BODY32

Reporting complete

Clear

Dose from Modality - Images

- **Images are insufficient**
  - technique only
    - kVP,mAs, not usually CTDIvol
    - not DLP, which spans entire acquisition
  - multiple reconstructions per exposure
    - soft tissue and bone reconstructions, MPRs
    - might count more than once
  - timing of encoding
    - images encoded/sent before acquisition ends

Dose from Modality - MPPS

- **MPPS is insufficient**
  - limited ability to encode complex data
  - transient message, nor a persistent object
  - cannot be “stored” long term or queried
  - intended to manage scheduling system
  - not very widely implemented in RIS/PACS
  - perceived as offering little benefit in addition to modality work list
  - historically some use in XA/RF

Conclusion

- **Infrastructure must support RDSR**
- **New & updated modalities: make RDSR**
- **Older modalities (and archive): OCR dose screens to make RDSR**
- **Ancient modalities: worth estimating from technique in image headers?**

- **Should be no need to record manually**