Patient Dose Tracking for Imaging Studies

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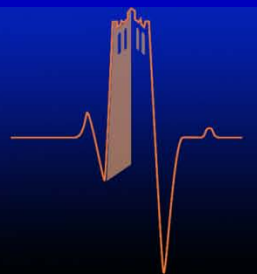
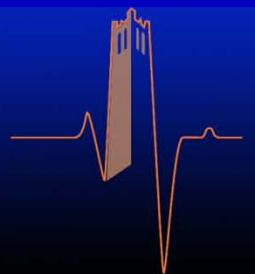


Conflict of Interest Statement

No affiliation or financial interests in any of the commercial products or enterprises discussed as part of this presentation.



Introduction to Patient Dose Tracking (PDT)

Why Patient Dose Tracking (PDT)?

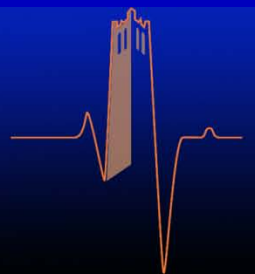
What Dose Metrics are useful/attainable?

How are dose metrics obtained?

Where are dose metrics recorded?

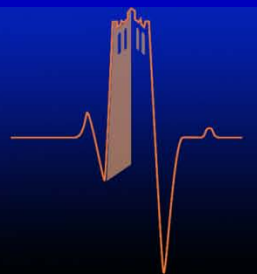
When is PDT required?

What tools are available to assist with PDT?



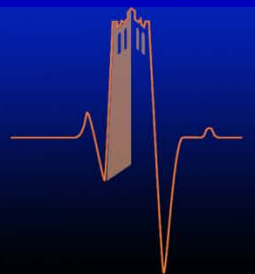
Overview

- Motivation
- Dose Metrics
- PDT “Requirements”
  - Regulatory
  - Accreditation
- Strategies & Tools for PDT
- Examples of Commercial Products



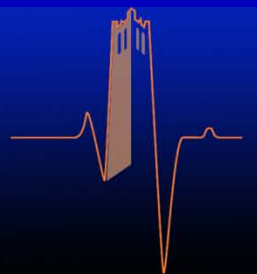
Why track Patient Dose?

- Regulatory requirements
- Accreditation requirements
- Liability and Public Relations
- Research
- Quality Assurance
- Awareness & Patient Safety
- Individual Patient cumulative dose record
- PQI



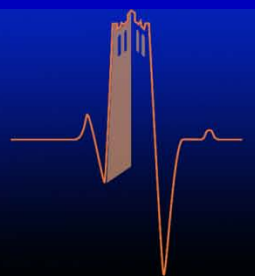
Patient Dose Metrics

- Dose
  - Organ Dose (Gy) /Equivalent Dose (Sv)
  - Effective Dose (Sv)
- Dose Surrogates
  - Cumulative Exposure Time (min)
  - Entrance Air Kerma (Gy)
  - Dose Area Product (Gy- cm^2)
  - Cumulative Dose (Gy)
  - Peak Skin Dose (Gy)
  - CTDI (Gy)
  - Dose Length Product (Gy-cm)
  - Size Specific Dose Estimate (Gy)



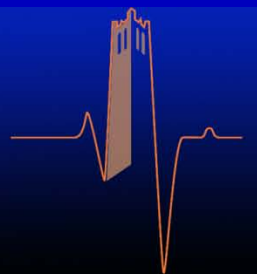
Individual Patient Dose Measurement

- Measurement of Patient Dose –Difficult
  - Dosimeters
  - Computational Predictions
- Dose Surrogates – Easier to obtain
  - Easier measurement
  - Difficult interpretation for radiation detriment
  - Not uniformly defined or applied
- Depend on biological endpoint



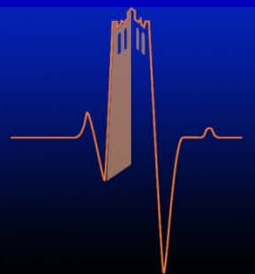
The dosimetry parameter that best represents the stochastic radiation detriment to a patient is

23%	a. Cumulative Dose
17%	b. $CTDI_{vol}$
13%	c. Dose Area Product
30%	d. Dose Length Product
17%	e. Effective Dose



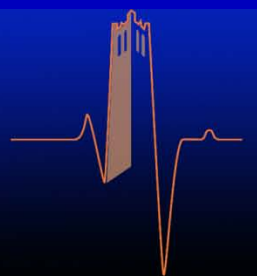
Answer: e. Effective Dose

Ref: Miller, et.al. Quality Improvement Guidelines for Recording Patient Radiation Dose in the Medical Record, J. Vasc. Interv. Radiology, 15:423-429, 2004.



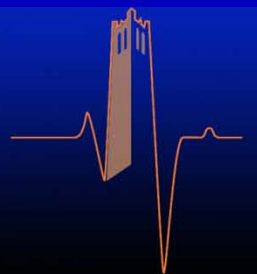
Requirements & Recommendations

- Federal
  - 21CFR 803: Reporting of skin damage to fluoroscopic equipment manufacturers
  - FDA Recommendations for Interventional Procedures
- States
  - CA, TX, OH……?
  - Fluoro and CT
- Other
  - Individual Health Care Systems
    - Veterans Health Administration & NIH
  - American College of Radiology , Dose Index Registry
  - The Joint Commission

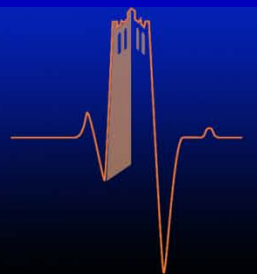


Sample Recommendations for Dose Metrics

- California: Effective Dose, Skin Dose
- Texas:
  - Reference Levels
  - Fluoro: Air kerma, or other estimates of skin dose
  - CT: $CTDI_{vol}$, DLP
- VHA:
  - Cumulative fluoro time
  - Cumulative air kerma or skin dose
  - Dose-area-product



- Recorded PDT Metrics likely dictated by regulatory and accreditation bodies

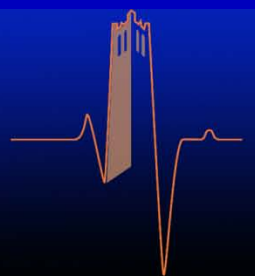


Requirements : California

- Senate Bill 1237
- Report to DHS scans that are repeated or wrong body part resulting in:
  - Effective Dose > 0.05 Sv
  - Dose > 0.5 Sv to any organ or tissue
  - Shallow dose to skin > 0.5 Sv
- Some exceptions
- Implementation: Reference levels for CTDIvol and DLP
- Exam and patient specific
  - i.e. Cumulative CTDIvol of 650 mGy for any → expected to exceed skin reporting threshold of 500 mSv

Requirements : Texas

- 25 TAC 289.227 – Effective May 1, 2013
- Radiation Protocol Committee for
  - Fluoroscopically-Guided Interventional Procedures
  - CT Systems
  - Methods to monitor radiation output
  - Establish Reference Levels for radiation output
  - Actions for when reference level is exceeded
  - Do not need to determine patient dose for each procedure



Requirements: Texas

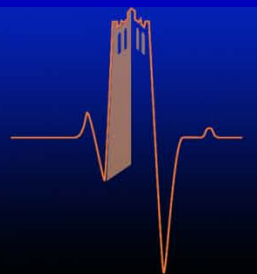
- Fluoroscopy
  - Make and maintain a record of radiation output information so the radiation dose to the skin may be estimated….
  - To include:
    - Cumulative air kerma or dose area product (if available on system) or
    - Fluoro mode, Cumulative exposure time & number of recorded exposures.
- CT
  - Make and maintain a record of radiation output information so the radiation dose to the skin may be estimated….
    - CTDIvol and DLP (if system capable of calculating and displaying) or
    - AAPM TG 111 Recommendations

Proposed: Ohio 3701: 1-66-07 (3/3/2014)

- Fluoro: Interventional, cardiac cath pediatric, pregnant patients
- Record cumulative air kerma or DAP for each exam

or

- Mode of operation, Cumulative fluoro exposure time, and number of radiographs



The State of Texas requires monitoring of patient doses for

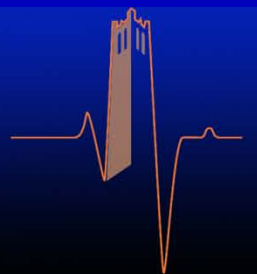
17% a. Radiography and Fluoroscopy

30% b. Fluoroscopy and CT

30% c. Radiography and CT

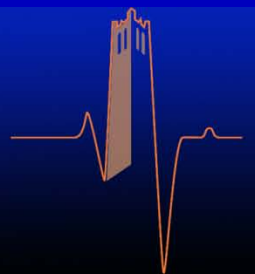
17% d. Fluoroscopy only

7% e. CT only



Answer: b. Fluoroscopy and CT

Ref: 25 Texas Adminstrative Code §289.227 "Use of Radiation Machines in the Healing Arts" May 2013.



Proposed: The Joint Commission

- Prepublication Standards: Diagnostic Imaging Services Requirements ; Provision of Care, Treatment, and Services (PC) – Effective July 1, 2014

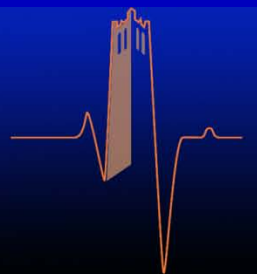
- PC.01.02.15 ; C5
- For …diagnostic CT….documents in the patient's medical record the radiation dose (CTDIvol or DLP) on every study produced during a CT examination.

- PC.01.02.15 ; C6

- For… diagnostic CT.. The interpretive report of a diagnostic CT study includes the CTDIvol or DLP radation dose. The Dose is either recorded in the patient's interpretive report or included on the protocol page.

- Only applicable for systems calculating and displaying radiation doses.

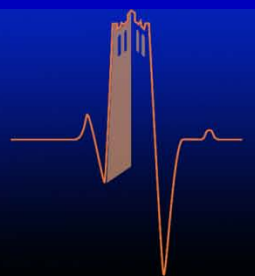
- Not applicable to systems for rad therapy treatment planning or dental cone beam CT



Proposed: The Joint Commission

- Prepublication Standards: Diagnostic Imaging Services Requirements ; Performance Improvement (PI) – Effective July 1, 2014

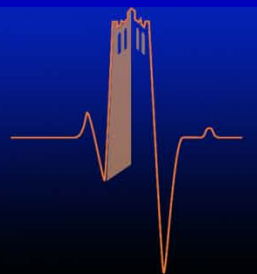
- PI.02.01.01; A6
- The hospital compiles and analyzes data on patient CT radiation doses and compares it with external benchmarks, when such benchmarks are available.
  - i.e. collection of data where pre-identified radiation dose limits are exceeded.



Observations on proposed TJC standards

- Draft requirement for electronic transmission of protocol identifying radiation dose to PACS was removed from the standard.

- Expect a parallel set of Fluoroscopy standards in Phase 2 – 2015 Implementation.



Effective July 1, 2014,The Joint Commission accreditation will require documentation of each patient's radiation dose ($CTDI_{vol}$ or DLP)

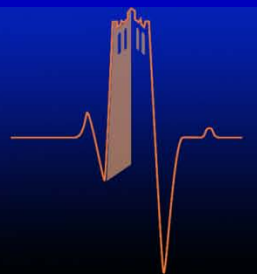
10% a. in the patient medical record.

33% b. by electronic transmission to the EMR.

20% c. by electronic transmission to the hospital's electronic PACS.

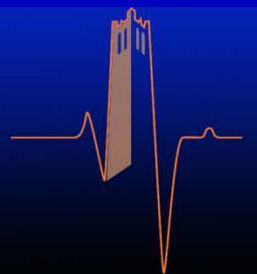
20% d. for diagnostic CT and dental cone beam CT systems.

17% e. by a diagnostic medical physicist



Answer: a. in the patient medical record.

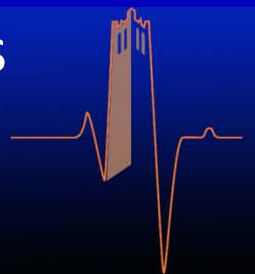
Ref: TJC Prepublication Standard PC.01.02.15



Generation& Recording of Dose Metrics

- Measured vs Predicted
  - DAP: measured
  - Cumulative Air Kerma/Skin Dose: Measured
  - CTDI : Predicted
  - DLP: Predicted
- Recording Methods
  - Manual
  - DICOM Radiation Dose Structure Report RDSR

    Or other electronic transfer formats
  - Optical Character Recognition (OCR) from images

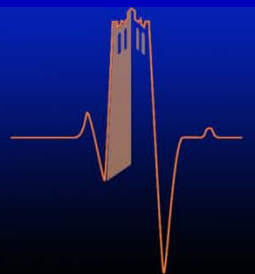


Formats & Imaging Modalities

- DICOM Radiation Dose Structured Report
  - RDSR
- DICOM Modality Performed Procedure Step
  - MPPS
- IHE profile Radiation Exposure Monitoring

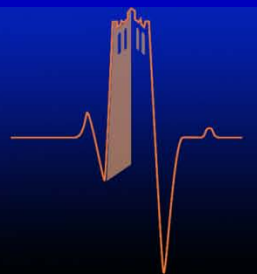
Digital Modalities these are typically provided for:

- CT
- Fluoro:
  - Interventional Radiography
  - Cardio-Vascular
  - Mobile C-Arms
- Radiography
- Mammography



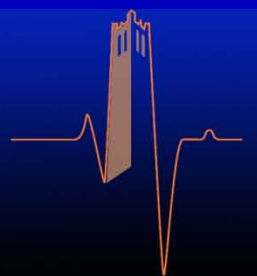
Options for Legacy Equipment

- Manual entry / Logs
- Image Headers
- OCR from Images



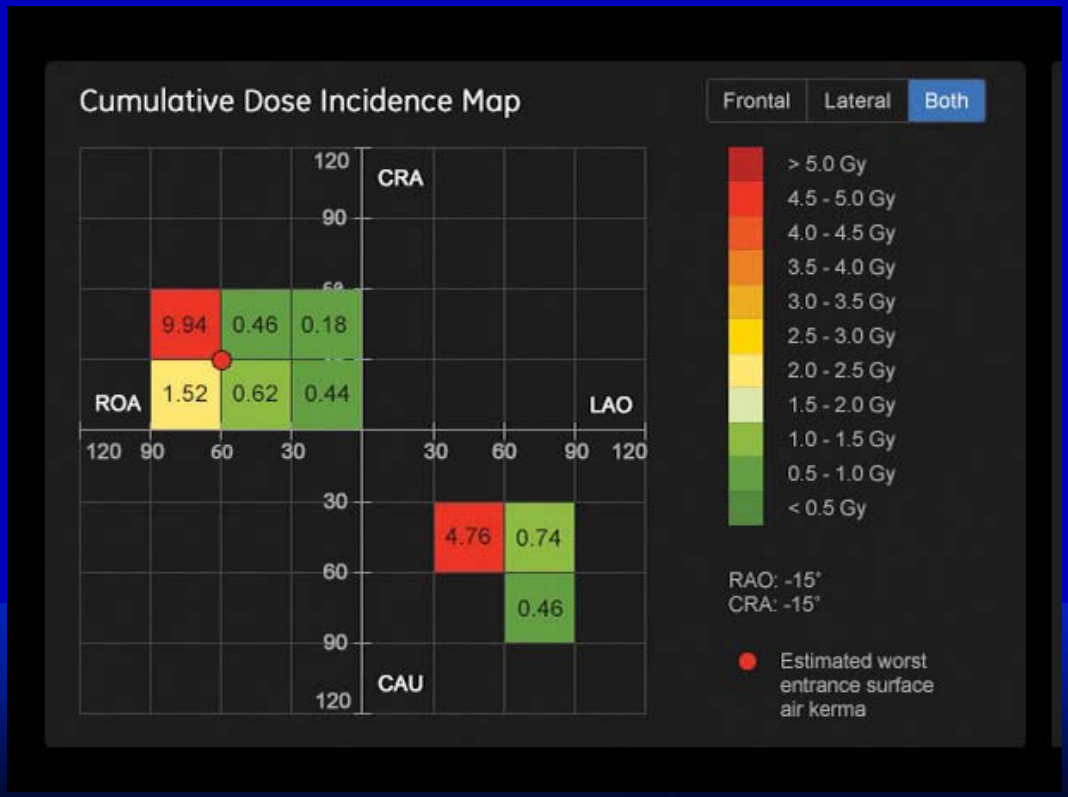
Dose Tracking Applications

- Cumulative dose tracking throughout a health system (multiple modalities and procedures).
- Analysis to optimize image quality and minimize patient risk
- Compliance and Reporting:
  - Internal
  - Patients
  - Governing & regulatory authorities



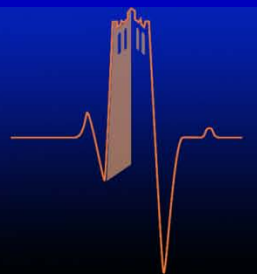
Patient Dose Tracking

- Threshold dose notifications
- Cumulative dose history prior to exams



Trend Analysis

- Dose comparisons as a function of
  - Modality
  - Protocol
  - Sites
  - Patient populations
  - Time
  - Etc.

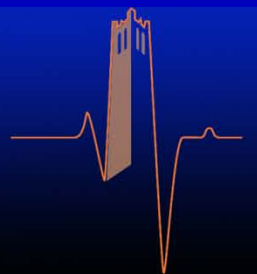


Compliance Reporting

- Periodic Summary Reports
- Customized Diagnostic Reference Levels

Communication with other systems

- PACS
- RIS
- HIS
- EMR
- ACR DIR



Dose tracking software systems can integrate dose information from each of the following methods *except*

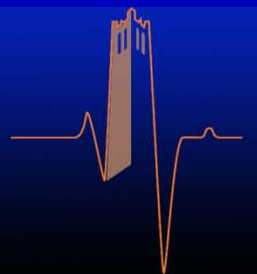
40% a. DICOM MPPS

17% b. DICOM RDSR

10% c. IHE Profile REM

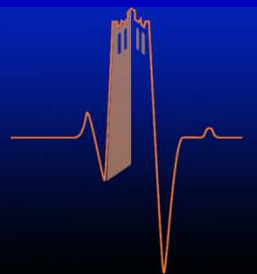
20% d. NEMA OS-3-2012

13% e. OCR



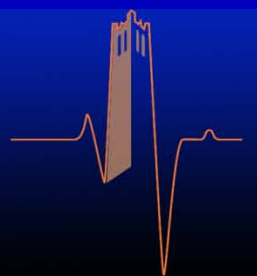
Answer: d. NEMA OS 3-2012

Ref: Manufacturer Websites listed at end of presentation



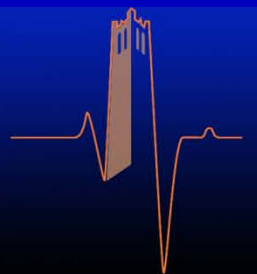
Commercial Solutions for Dose Tracking

- Broad range of capabilities
  - Basic information recording
  - Advanced analysis and interactive notification
- Multi-modality
- Transmission of dose information from imaging device or PACS
- Integration with PACS, RIS, & EMR
- Analysis and Reporting



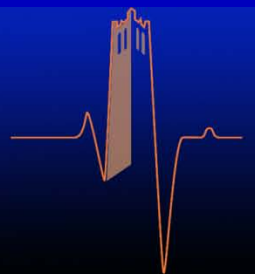
Commercial PDT Tools

- Basic
- Custom
- Dedicated System



Basic Dose Tracking

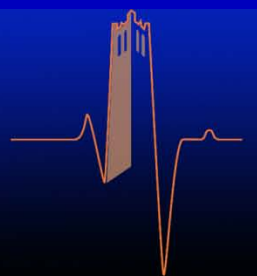
- Integrated with an existing system
- Example: Meditech
  - Integrated information system
  - Many aspects of health care
  - Includes a RIS and interfaces with PACS
  - RDSR's flow into Meditech
  - Subsequently recorded in patient record



Custom Applications

- Designed to meet specific needs
- Example: Primordial
  - Customized applications in radiology
  - Provide wide variety of Radiology services
  - Departmental workflow, communications, QC,...
  - Integration of PACS, RIS, and EMR

  - Radiation Dose Monitoring – Customizable Application



Dedicated Dose Tracking Software

Integrate dose metrics from imaging systems or PACS

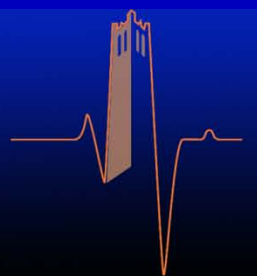
typical formats: DICOM RDSR preferred

Integrate with PACS, RIS, EMR

Analysis capabilities

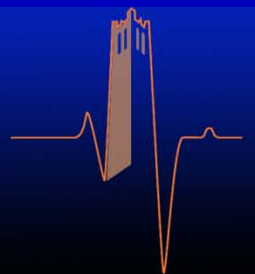
Selection of Reference Doses

Automated notification



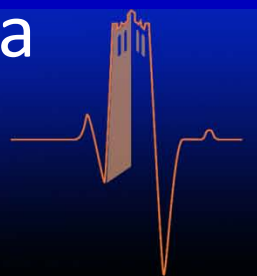
Examples of Dedicated Dose Tracking Systems

- DoseMonitor (PACS Health)
- DoseTrack (Sectra)
- DoseWatch (GE)
- RADAR360 (MedPhys360)
- Radimetrics/eXposure(Bayer)



Common Features

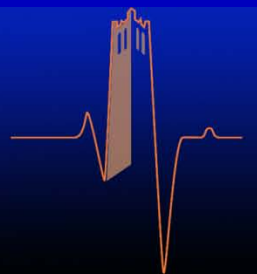
- DICOM or IHE standards for interfaces
- Single server web-based applications
- Interface with multiple modalities
  - CT, Mammo, DR, Interventional vascular, Cardiac angiography, mobile C-arms
- HL7 Interface with PACS
- Customization for Ref. dose alerts
- Provide Near-time dose feedback
- Upload to ACR Dose Index Registry
- SSDE Prediction – Based on patient EMR data



DOSEMONITOR®

by PHS Technologies Group

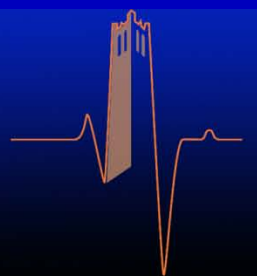
- 2012
- Single server, browser based design
- Direct integration with RIS, EMR, ACR DIR
- Supports CT, Mammo, DR, IV, CA



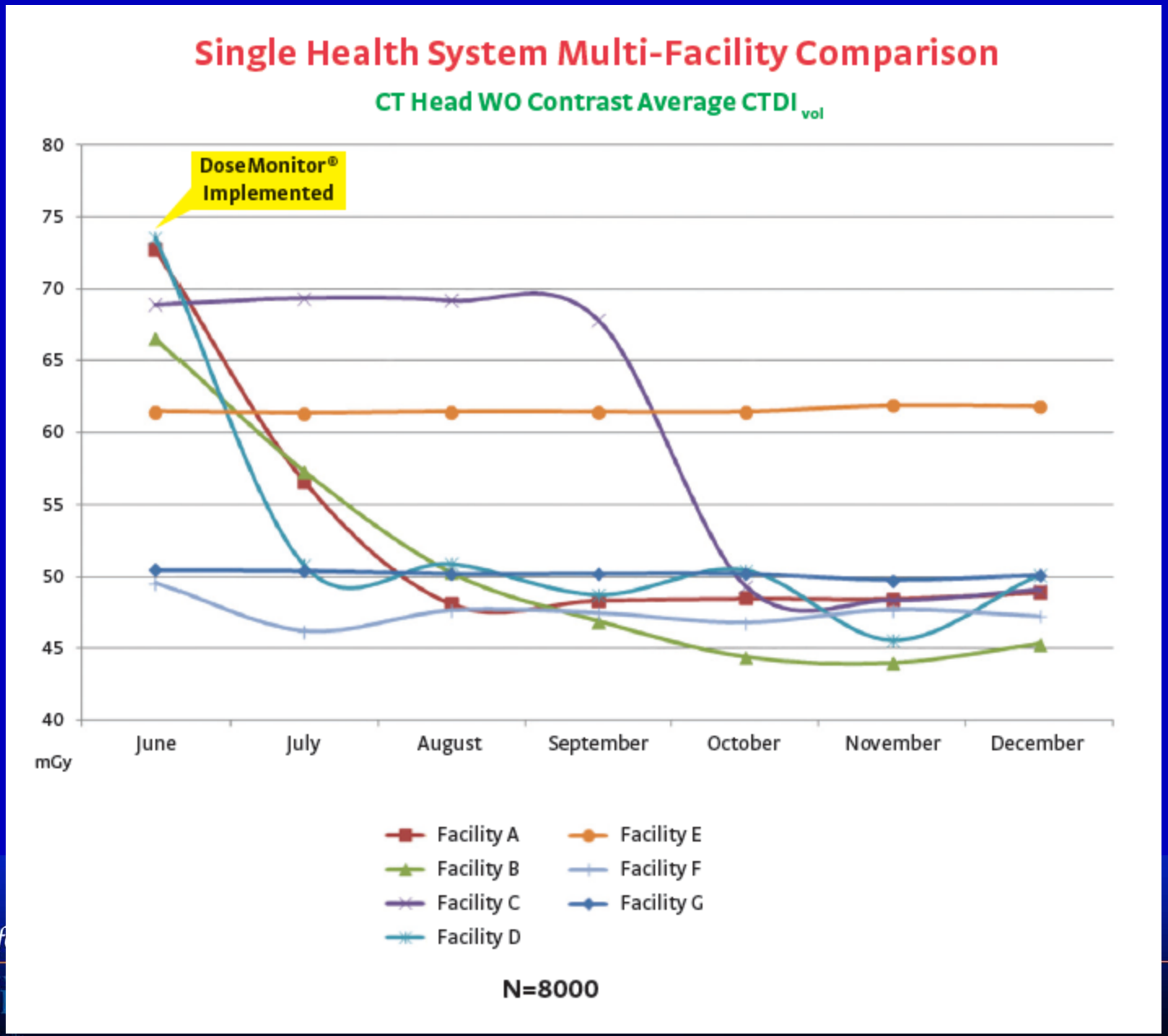
DOSEMONITOR®

Features and Capabilities:

- Patient historical dose repository
- Customizable alerts and notifications
- Dose data exportable to dictation
- Reporting – sort by
  - Technologist
  - Procedure
  - Physician

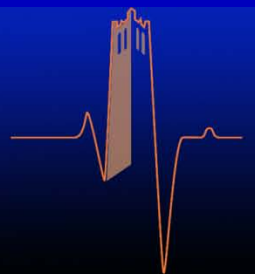


- 8000 studies over 6 months



RADAR360 by MedPhys360

- Radiation Dose Analyzing & Reporting
- Queries PACS for CT data
- CTDI & DLP Analyis
- Protocol Management
- Pediatric Techniques Evaluation
- Customizable – designed to be affordable



Radiation Dose Analysis and Reporting - (RADAR)

File View Reports CT Protocols Admin

Pediatric Snapshot

Pediatric Scan Alert: View Alerts

View Graph By: ctdi

Average Technique

	Average	Max
kV	111.11	120.00
mA	292.85	468.14
CTDI	39.79	57.24

General CT Data

Scan Alert: No

Click To View Alert

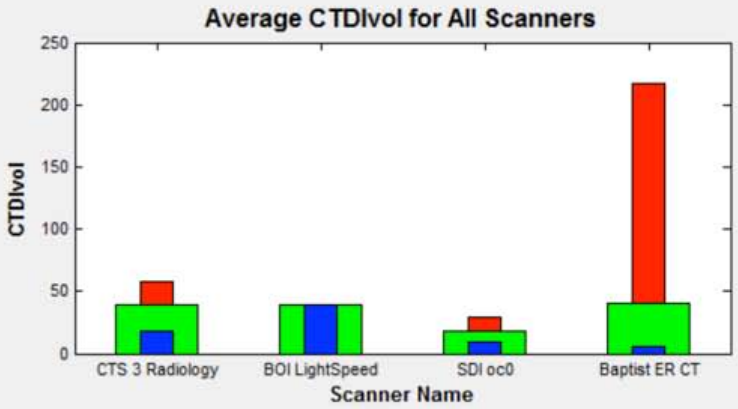
Data Logs

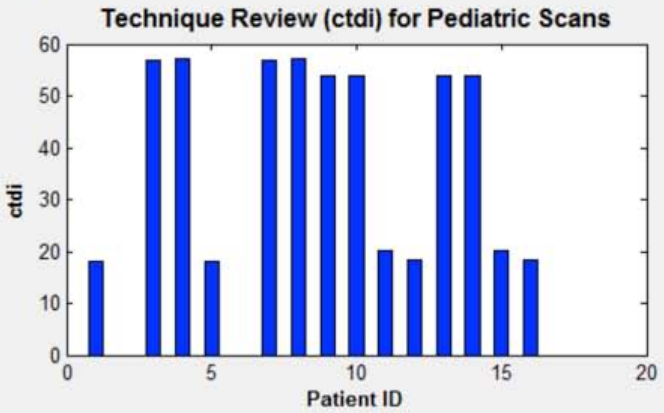
Extraction Error Logs: View

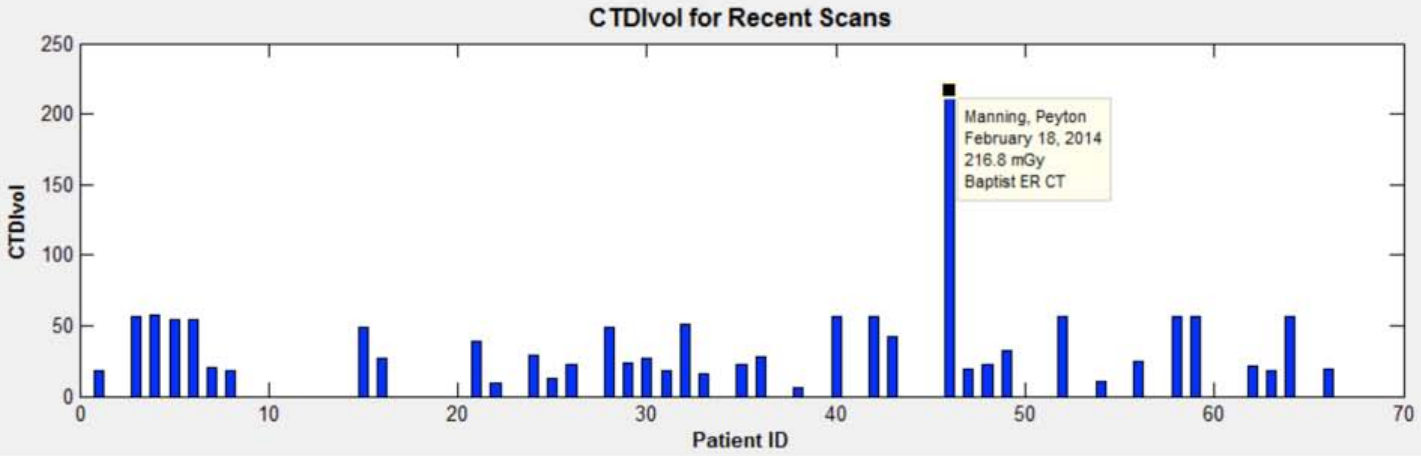
Out-of-Tolerance Logs: View

New Protocol Discovered: View

CTDI Data Snapshot



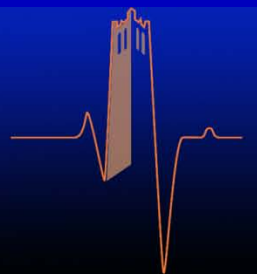




SECTRA

DoseTrack by Sectra

- Cloud based dose monitoring
- Supports CT, Mammo, DR, IV, CA
- Alerts when thresholds exceeded
  - i.e. User defined Dose Reference Levels
- Fluoro cumulative dose maps
- Analysis:
  - Patient specific
  - Dose profiles for imaging systems
  - Comparison of individual performance



Dashboard | Patient | CT | Fluoro/Angio | Conventional X-Ray | Mammography | Classic | About

Search

Current Selection: 34/405,926

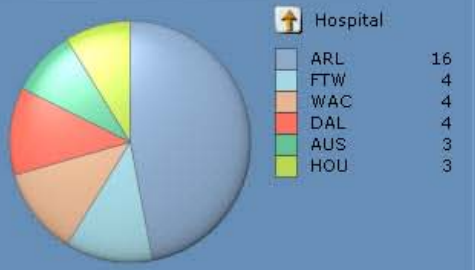
ModalityC... CT

radiation_... ("SENT" | "SENDING")

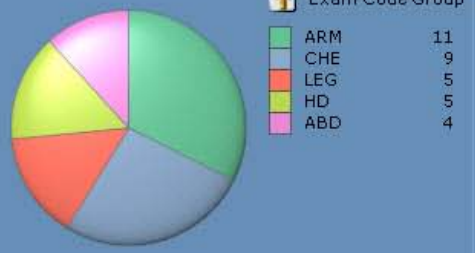
< Clear Selection >

Select by chart | Select by parameter

US - TX



CT



Calculation based on 353,080 studies

DDB: 1030 mGy*cm

Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec

2007 | 2008 | 2009 | 2010 | 2011 | 2012

SECTRA

Scorecard | Histogram | Trend | Scatter | Age distribution | Study table | Series table | Extra info

Location	Modality	Mod Count	Studies	Benchmark (DLPtot)	Max DLPtot mGy*cm	Median CTDIvol (mGy)	First	Radiation Alerts
Total		**13**	**34**		**10.112.0**	**13.71**	**06-Nov-2008**	**34**
ARL-ER-1093A	CT	1	5		10,112.0	26.92	23-Jul-2009	5
ARL-ER-1094	CT	1	4		3,848.0	11.22	04-Jul-2011	4
FTW-XR-LAB6	CT	1	4		3,948.3	20.21	08-May-2009	4
WAC-XR-11	CT	1	4		3,141.0	15.50	27-Mar-2011	4
ARL-CT-1069	CT	1	3		3,168.0	8.51	06-Nov-2008	3
ARL-NEURO-1067	CT	1	3		3,279.7	18.70	27-Aug-2009	3
AUS-XR-LAB15	CT	1	3		1,059.2	4.60	30-Sep-2009	3
DAL-XR-LABCT	CT	1	3		2,795.2	10.74	08-Mar-2010	3
ARL-CT-4080	CT	1	1		74.0	8.56	24-Oct-2011	1
DAL-XR-CT2	CT	1	1		517.1	0.07	27-Mar-2011	1
HOU-NEURO-36	CT	1	1		2,868.0	56.87	08-Jan-2010	1
HOU-XR1-2	CT	1	1		101.3	0.69	26-Mar-2012	1
HOU-XR1-12	CT	1	1		409.4	8.33	19-Aug-2010	1

Sex

F

M

Patient Age

0 20 40 60 79 99 119

Height in cm

18 48 78 108 138 168

Weight in kg

0 18 36 54 73 91 109

In hours

Start = 09:00

End = 17:00

Adult | Paediatrics

In hours | Out of hours

UF UNIVERSITY of FLORIDA

J. Crayton Pruitt Family Department of Biomedical Engineering

DoseTrack

Dashboard | Patient | CT | Fluoro / Angio | Conventional X-Ray | Mammo | Classic | About

Search

Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec

2008 | 2009 | 2010 | 2011 | 2012

Current Selection

Year 2011

Select by Chart | Select by parameter

Patient

- Patient ID
- Patient's name
- Sex
- Age
- Date of Birth

Study

- Requested Proc ID
- Accession Number
- ExamCodeGroup
- Exam Code
- Exam Description
- Prioritising Phys.
- Referring Phys.
- Performing Phys.
- Phantom
- MPPS Status
- Month
- Radiation Alert

Location

- Hospital
- Department
- Room

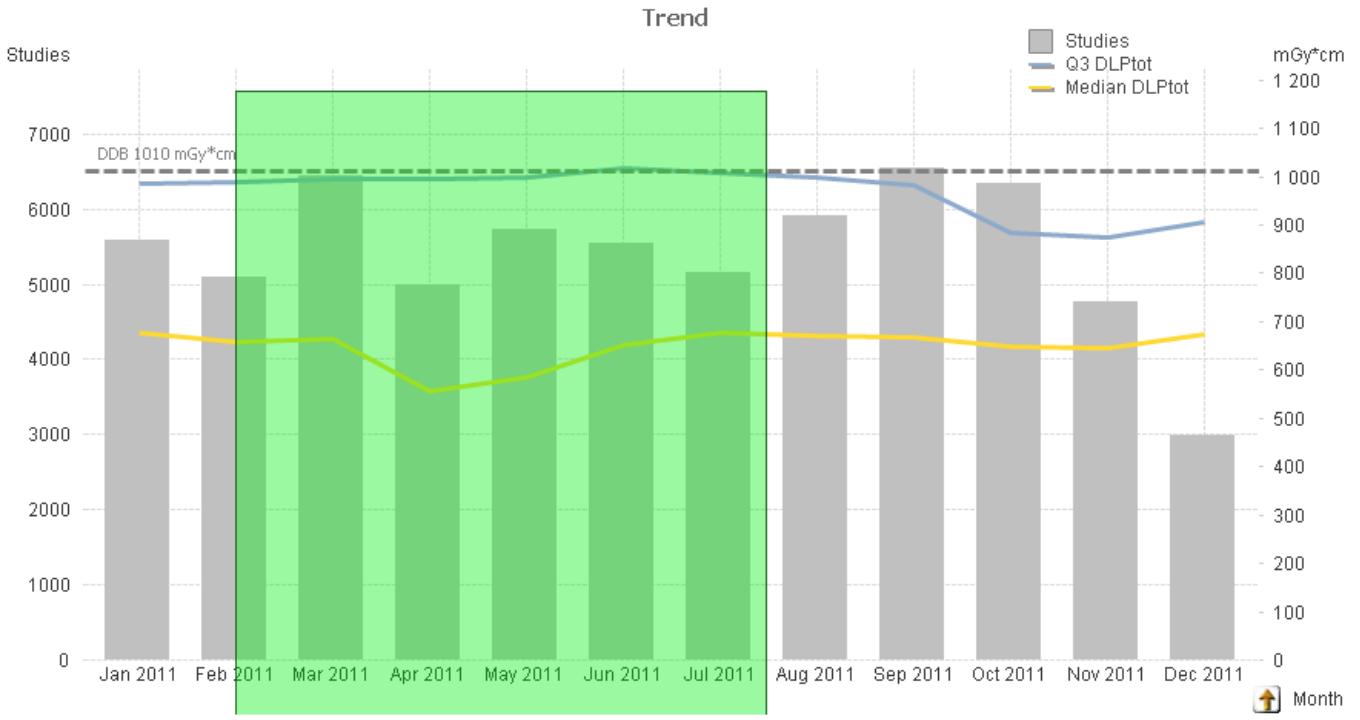
Equipment

- Manufacturer
- Model Name
- Category
- Modality Type
- Station Name
- Filter Material
- Validation Status

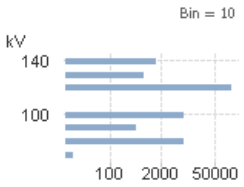
< | Clear Selection | >

Selecting 65059 of 224667 CT studies
Last update: 2012-07-06 16:42:08

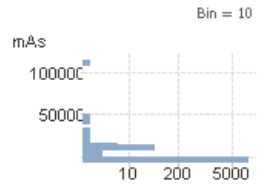
Scorecard | Histogram | Trend | Scatter | Age Distribution | Table (Study) | Table (Series)



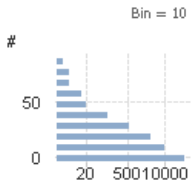
Tube Voltage Peak (kV)



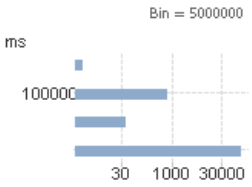
Exposure (mAs)



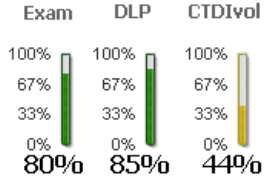
Number of Exposures



Exposure Time (ms)



Dataset Completeness



SECTRA

Department of Biomedical Engineering

Radimetrics (eXposure) by Bayer

- Stand alone system- in house server
- Integrates with PACS & RIS

- Patient Score Card
  - Cumulative dose tracking
- CT Dosimetry Prediction
  - Monte Carlo simulation engine
  - Organ doses
  - Effective dose
  - Protocol evaluation

Patient Scorecard

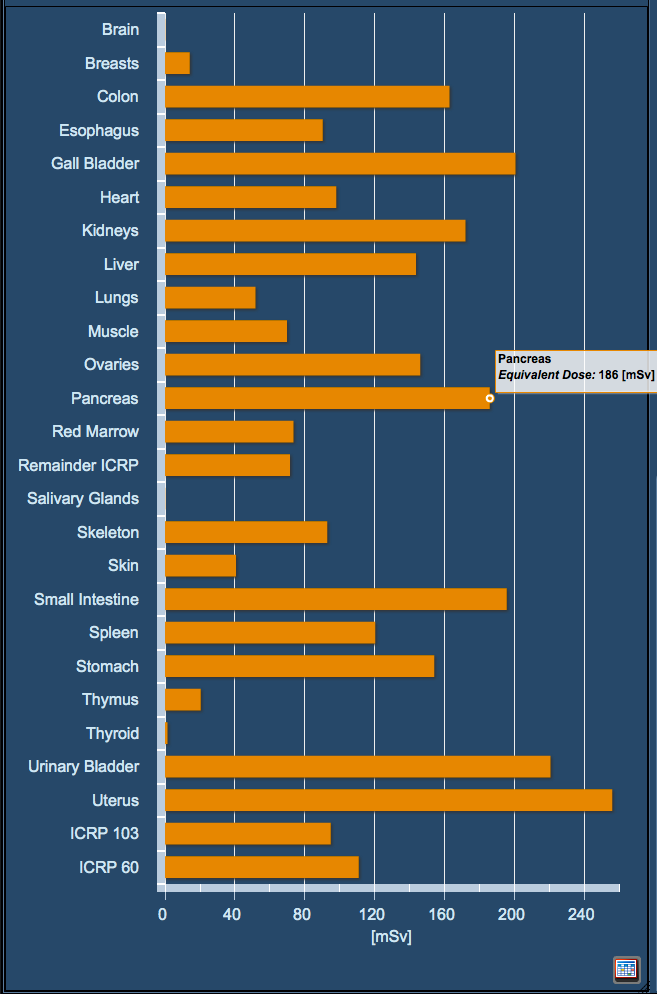
H192805 XXXXXX,XXXXXX

F DOB: 1934-06-08 Age: 77

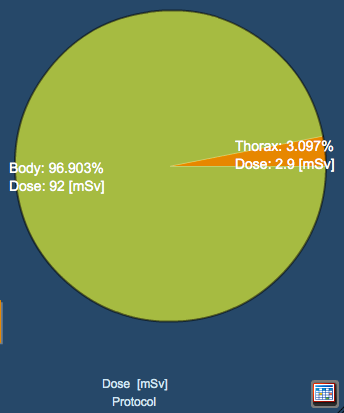
Scorecard | Examinations | Alerts | +

Effective Dose (CT)

Summary | ICRP 60 | ICRP 103 | +

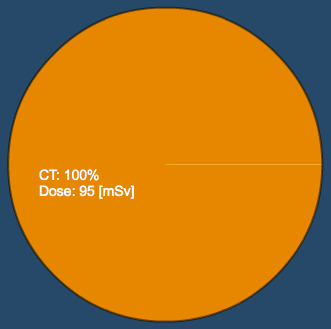


Dose by Protocol (CT sorted)



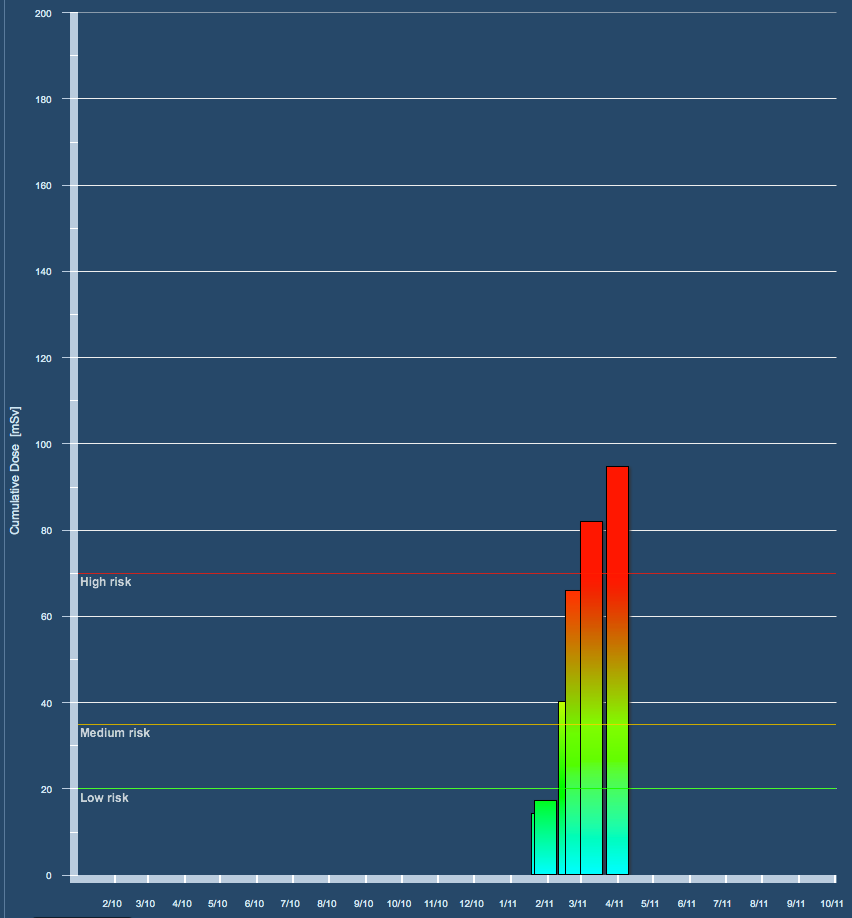
Dose [mSv]
Protocol

Modality



Dose [mSv]
Modality

Cumulative Dose



Dosimetry

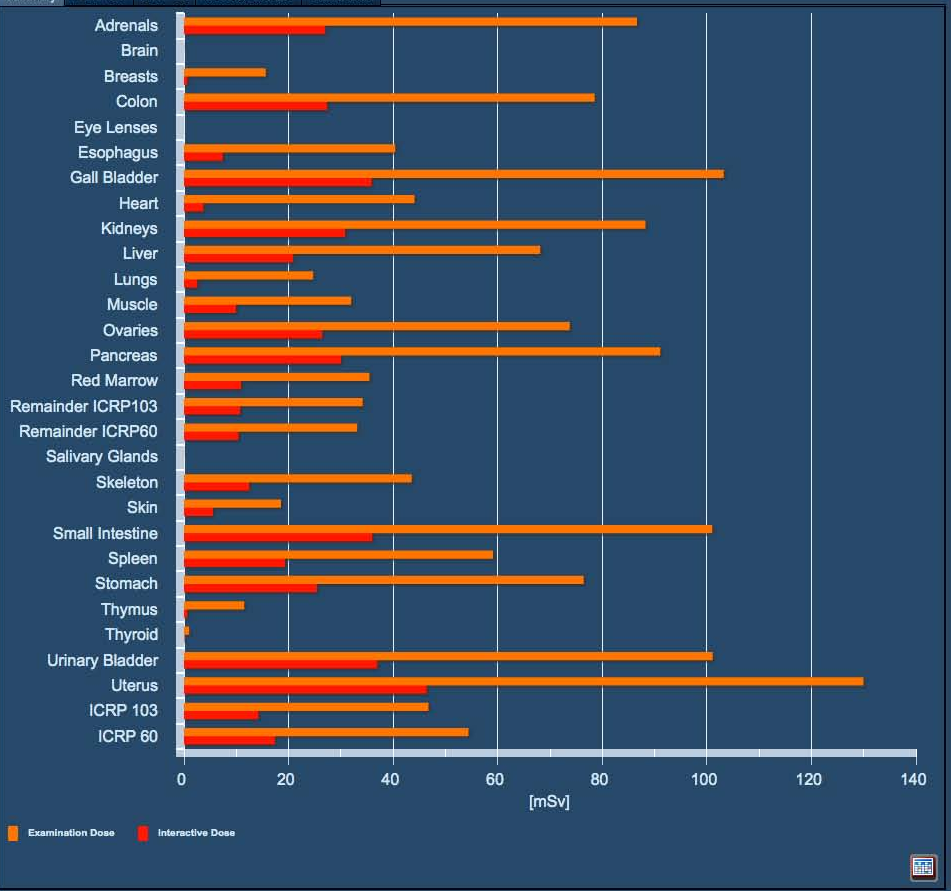
00068146 SIBOUNMA, CLARIBEL
F DOB: 1957-05-01 Age: 54

00368340 CT Abdomen WITHOUT/Abdomen
Performed: 2011-07-13 1:38 PM

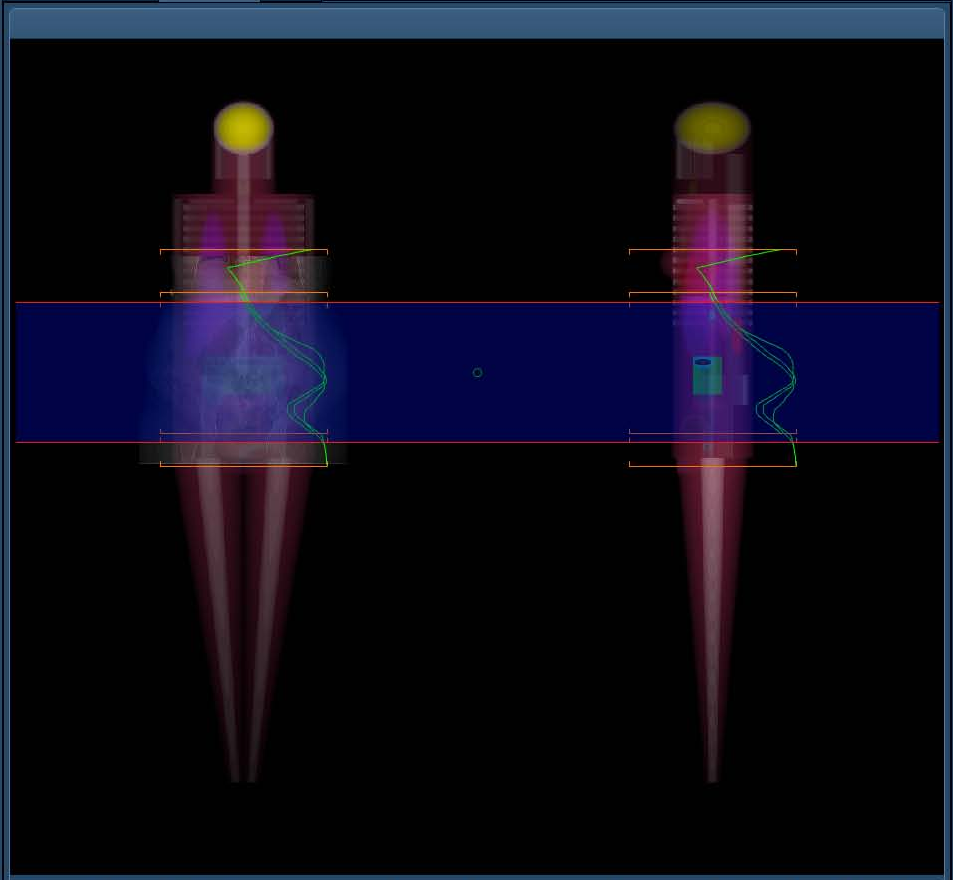
Dosimetry | Modulation | Localizers | Patient Protocols | Dose Reports | DICOM | Logbook

Effective Dose

Summary | ICRP 103 | ICRP 60 | K Factor Method | Simulations



Protocol Dose Distribution | Virtual Phantom | Protocol



Localizer | Phantom | Modulation | AP + LAT | Localizer | Scan Range 154 - 490 mm

Scan Parameters

Protocol Acquisitions

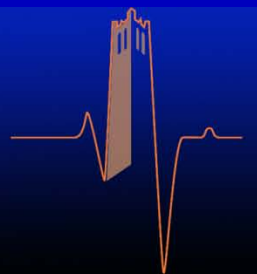
Examination Acquisitions

Radimetrics

- Protocol Management
  - Supports multiple scanners
  - Tracks & authorizes revisions
  - Set uniform dose reference levels
    (CTDI, DLP, E, Organ Dose)
- Reporting
  - Customizable dashboard
  - Select items of items of interest
  - Pateint Scorecard integrates with most EMR systems
- Productivity
  - Monitoring & Analysis of equipment utilization
  - Integrates with Contrast dose management tools

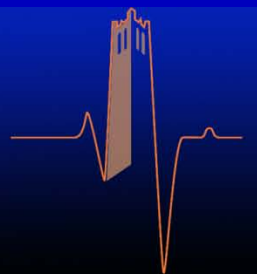
DoseWatch – GE HealthCare

- Multi-modality
- Not vendor specific
- Centralized system- web-based interface
- Integrates with RIS and EMR
- Tracking and statistical analysis
  - Identifies dose outliers
  - Email notification



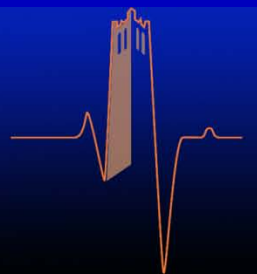
DoseWatch

- Reporting
  - By device, operator or protocol
  - User defined thresholds
  - Email notifications
- Trend analysis
  - Baselines for procedures
  - Benchmark for improvements/optimization

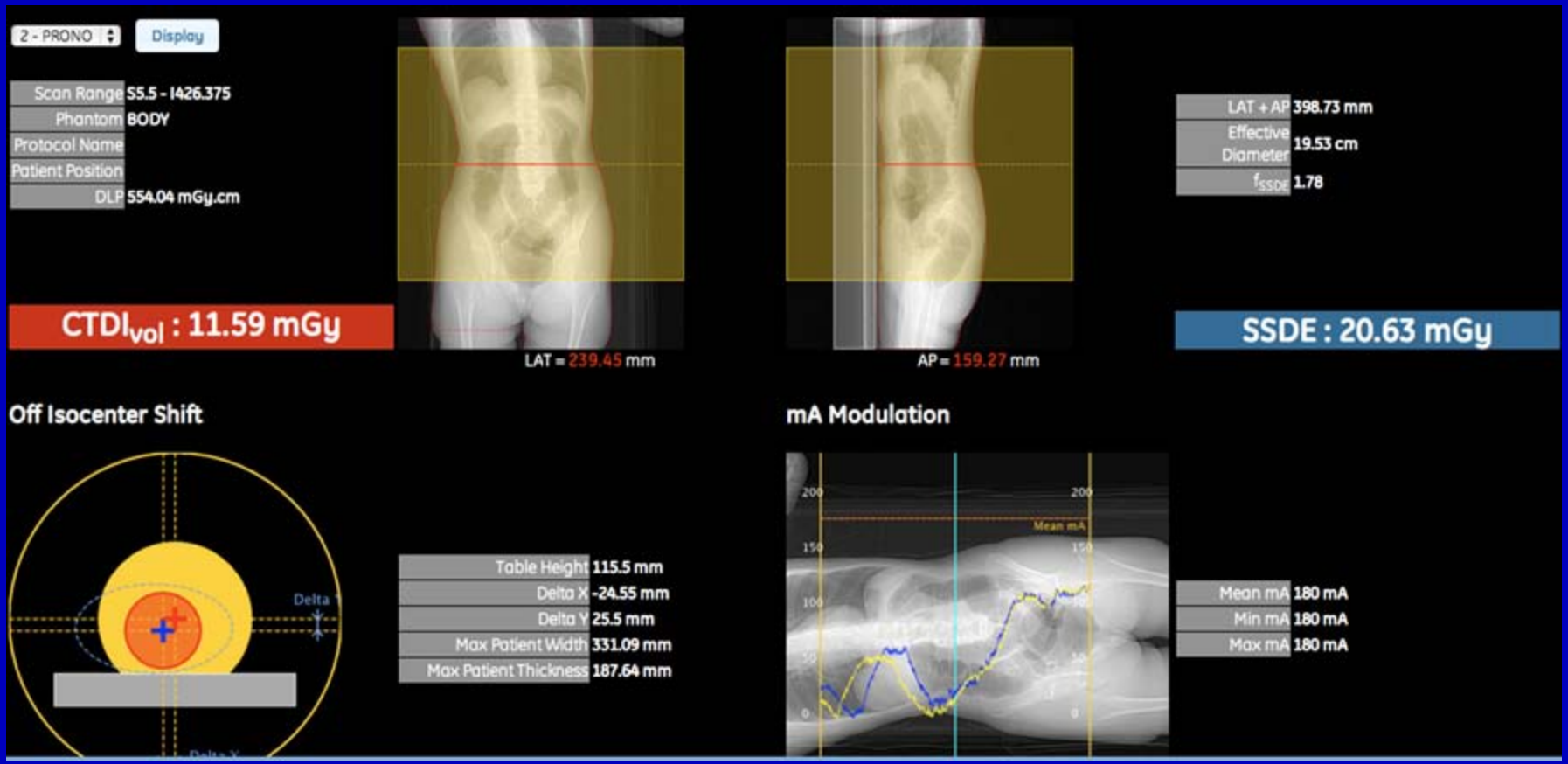


DoseWatch

- Legacy systems
  - Extracts dose info from OCR on dose report images
- CT : Size Specific Dose Estimate (SSDE)
  - Per AAPM TG 204
  - Based on scout images
- Fluoroscopy: Incidence Map



SSDE


2 - PRONO
Display
Scan Range 55.5 - 1426.375
Phantom BODY
Protocol Name
Patient Position
DLP 554.04 mGy.cm
CTDIvol : 11.59 mGy
LAT = 239.45 mm
AP = 159.27 mm
LAT + AP 398.73 mm
Effective Diameter 19.53 cm
fSSDE 1.78
SSDE : 20.63 mGy
Off Isocenter Shift
Delta
Table Height 115.5 mm
Delta X -24.55 mm
Delta Y 25.5 mm
Max Patient Width 331.09 mm
Max Patient Thickness 187.64 mm
mA Modulation
200
150
100
50
0
Mean mA
Mean mA 180 mA
Min mA 180 mA
Max mA 180 mA

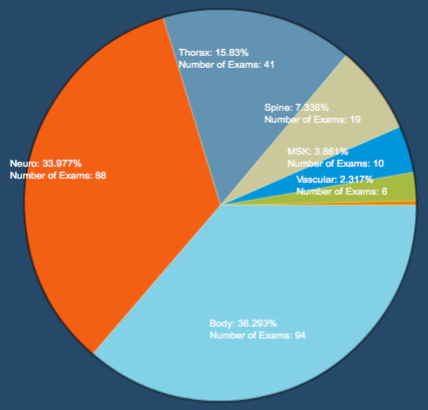
Dashboard | Patients | Examinations | Protocol Editor | Protocols | Dosimetry | Calibration | Configuration

Administrator | 1514/1514 | Settings | Logout

Overview | Utilization | Distributions | +

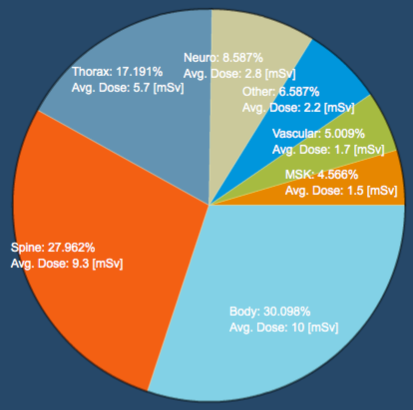
Current Month | 10/01/2011 | 10/11/2011

Exams / Equipment (QHC Belleville, qhcbect, CT, Belleville General Hospital, qhcbect - Brilliance 64)



Number of Exams
Exams / Equipment

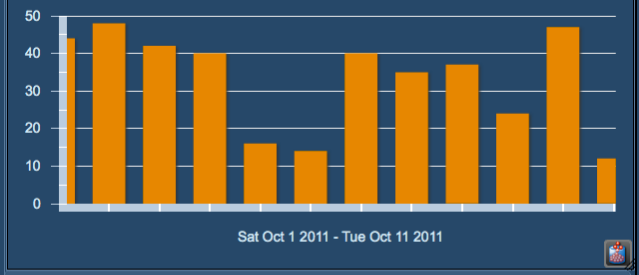
Dose by Equipment (QHC Belleville, qhcbect, CT, Belleville General Hospital, qhcbect - Brilliance 64)



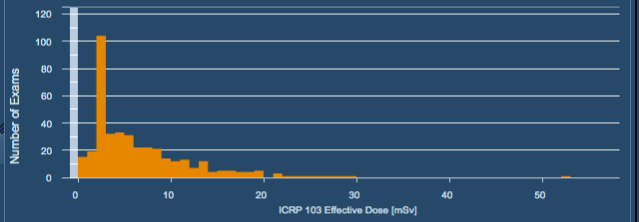
Avg. Dose [mSv]
Dose / Equipment

Device Monitor

Volume | Examinations | Activity

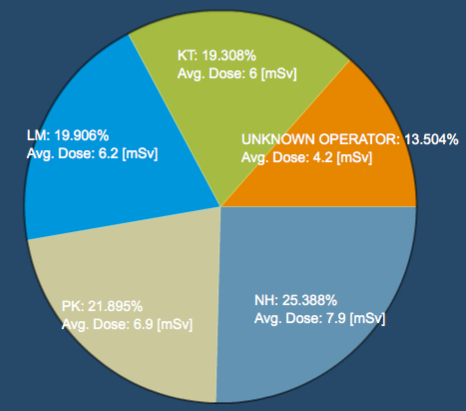


Dose Frequency Distribution



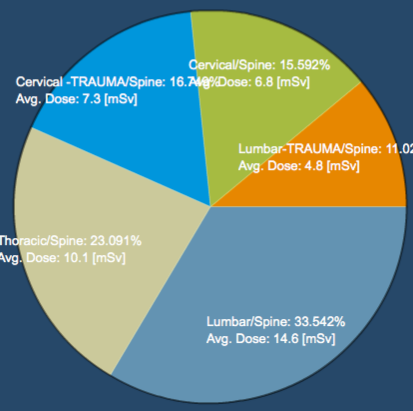
Dose Frequency Distribution

Dose by Operator (Unknown Operators, QHC Trenton Memorial Hospital)



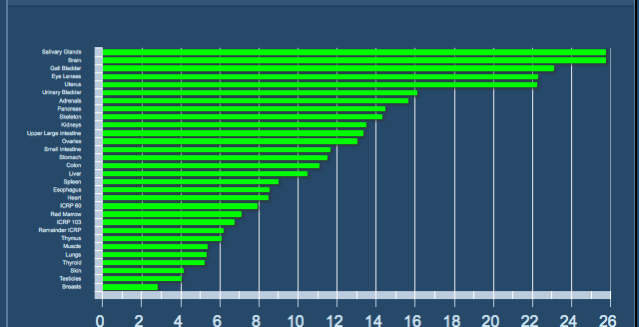
Avg. Dose [mSv]
Dose / Operator

Dose / Order (CT, Belleville General Hospital, Spine, SPINE (CT), CT, Belleville General Hospital, qhcbect

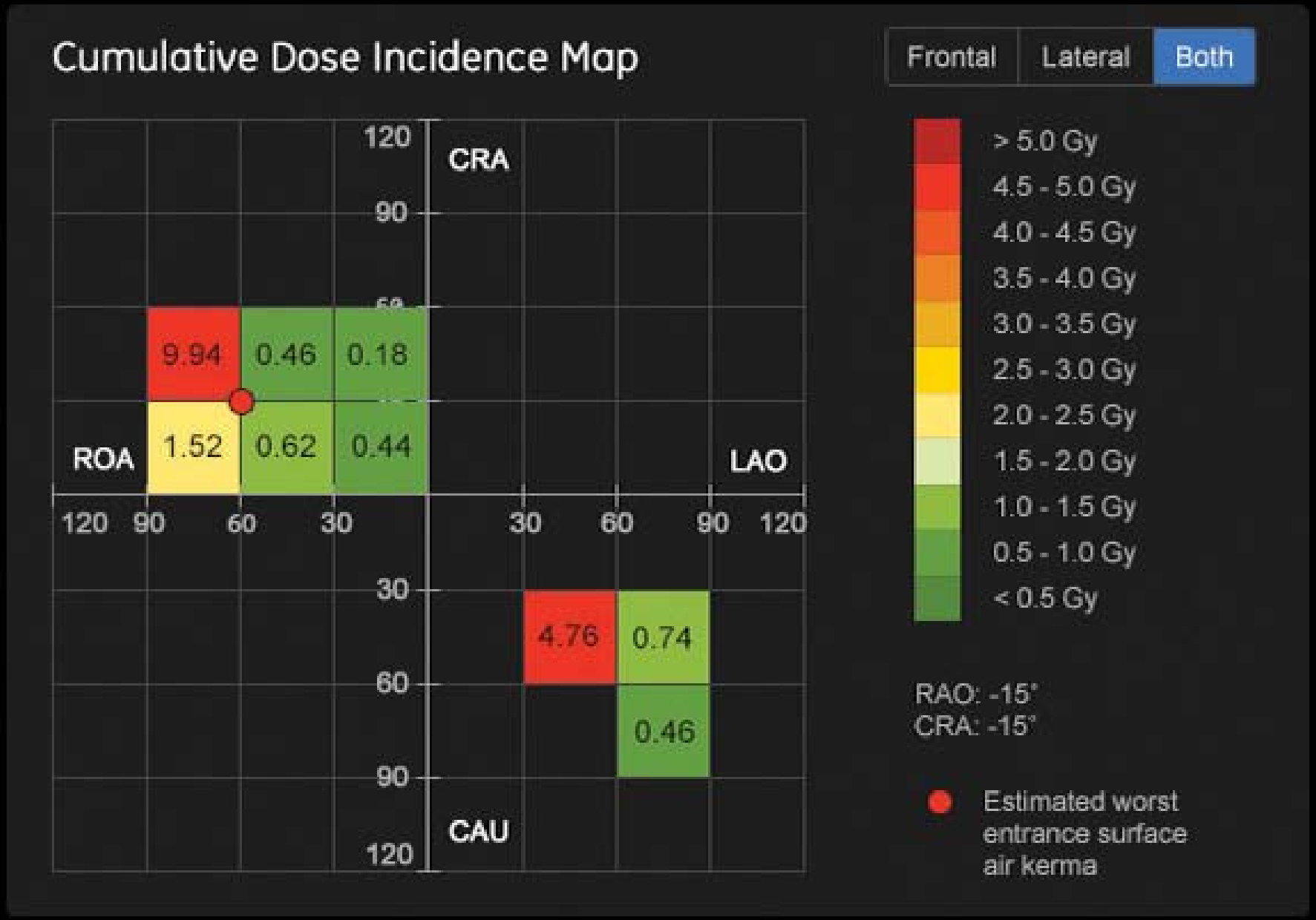


Avg. Dose [mSv]
Dose / Order

Dose by Anatomy



Dose / Anatomy


Cumulative Dose Incidence Map
Frontal
Lateral
Both
120
CRA
90
9.94
0.46
0.18
ROA
1.52
0.62
0.44
LAO
120 90 60 30
30 60 90 120
30
4.76
0.74
60
0.46
90
CAU
120
> 5.0 Gy
4.5 - 5.0 Gy
4.0 - 4.5 Gy
3.5 - 4.0 Gy
3.0 - 3.5 Gy
2.5 - 3.0 Gy
2.0 - 2.5 Gy
1.5 - 2.0 Gy
1.0 - 1.5 Gy
0.5 - 1.0 Gy
< 0.5 Gy
RAO: -15°
CRA: -15°
Estimated worst entrance surface air kerma

Effectiveness & Advances

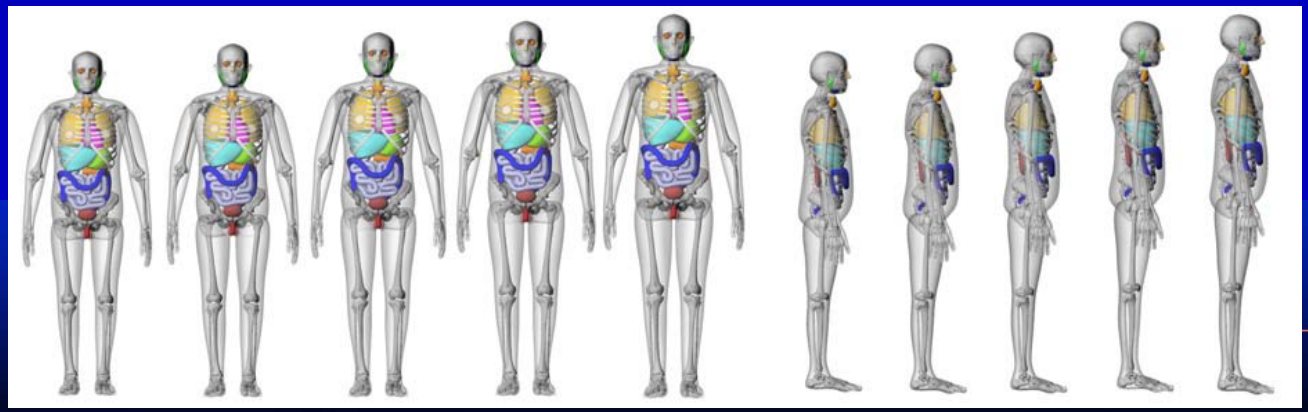
- Demonstrated reduction in patient doses
  - Even without extensive analysis
- Seamlessly satisfy recording requirements
- Management of doses, equipment, training
- Endless PQI possibilities

- Development of Real-Time Dose Monitoring
  - Fluoroscopy
  - Real-time integration & body mapping of fields using RDSR

Real-Time Skin Dose Mappng

- ***RDSR – Radiation Dose Structured Report***
- ***Collaboration with UF, UF Health Jacksonville and Columbia University Medical Center in NYC***

•PI : Wesley Bolch, Ph.D.

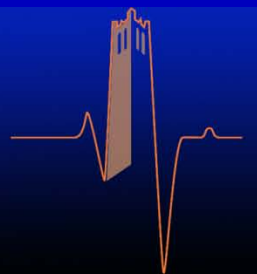


The cumulative dose incidence map provides

13%	a.	A planar represention of the surface air kerma distribution
20%	b.	A summary of the DAP per study
23%	c.	A visualization of cumulative organ doses through the body
13%	d.	The variation of a facilities cumulative delivered dose over time
30%	e.	A correlation of the number of studies performed with cumulative dose

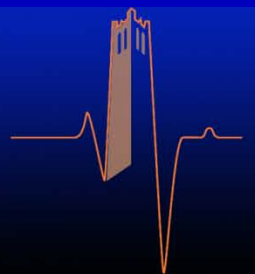
Answer: a. a planar representation of the surface air kerma distribution.

Ref: Manufacturer Websites listed at end of presentation



Summary

- Evolving Industry
  - Expect increasing numbers & advanced capabilities
- Products are readily customized to users needs
- Patient population or individual based applications
- Valuable QA tools
- Support regulatory focus & compliance
- Dose metrics not uniform across modality
  - Unavailable for legacy equipment
  - Integration of patient dose ?
- Integrate with other systems (PACS, EMR, RIS, HIS…)
- Difficult to track across health care systems



References

- 25 Texas Adminstrative Code §289.227 “Use of Radiation Machines in the Healing Arts” May 2013.
- VHA Handbook 1105.04, “Fluoroscopic Safety”, Department of Veterans Affairs, Veterans Health Administration, Washington, DC 20420, July 2012.
- Miller, et.al. Quality Improvement Guidelines for Recording Patient Radiation Dose in the Medical Record, J. Vasc. Interv. Radiology, 15:423-429, 2004.
- Amis, et. al. American College of Radiology White Paper on Radiation Dose in Medicine, J. Am. Coll. Radiol. 4: 272-284, 2007.
- Hospitals & Health Networks, Radiation dose management: A Patient Safety priority, Gatefold, 2013.
- The Joint Commission: Prepublication Standards: Diagnostic Imaging Services Requirements ; Provision of Care, Treatment, and Services, Dec 2013.
- 2014 Ambulatory Care, Critical Access Hospital, and Hospital Comprehensive Accreditation Manual – March 2014.

Commercial Product Web-Sites and Descriptions

- http://www.dosemonitor.com/
- http://www.radimetrics.com/
- http://www.sectra.com/medical/
- http://www.primordialdesign.com/
- http://www3.gehealthcare.com/en/Products/Dose_Management/DoseWatch
- http://medphys360.com