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Banner Health

CT Radiation Dose Tracking and Optimization at Banner Health

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About the Speaker







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I am not affiliated with any entities that present a conflict of interest for the information presented in this slide deck.

Please silence your mobile devices.

Active participation is encouraged.

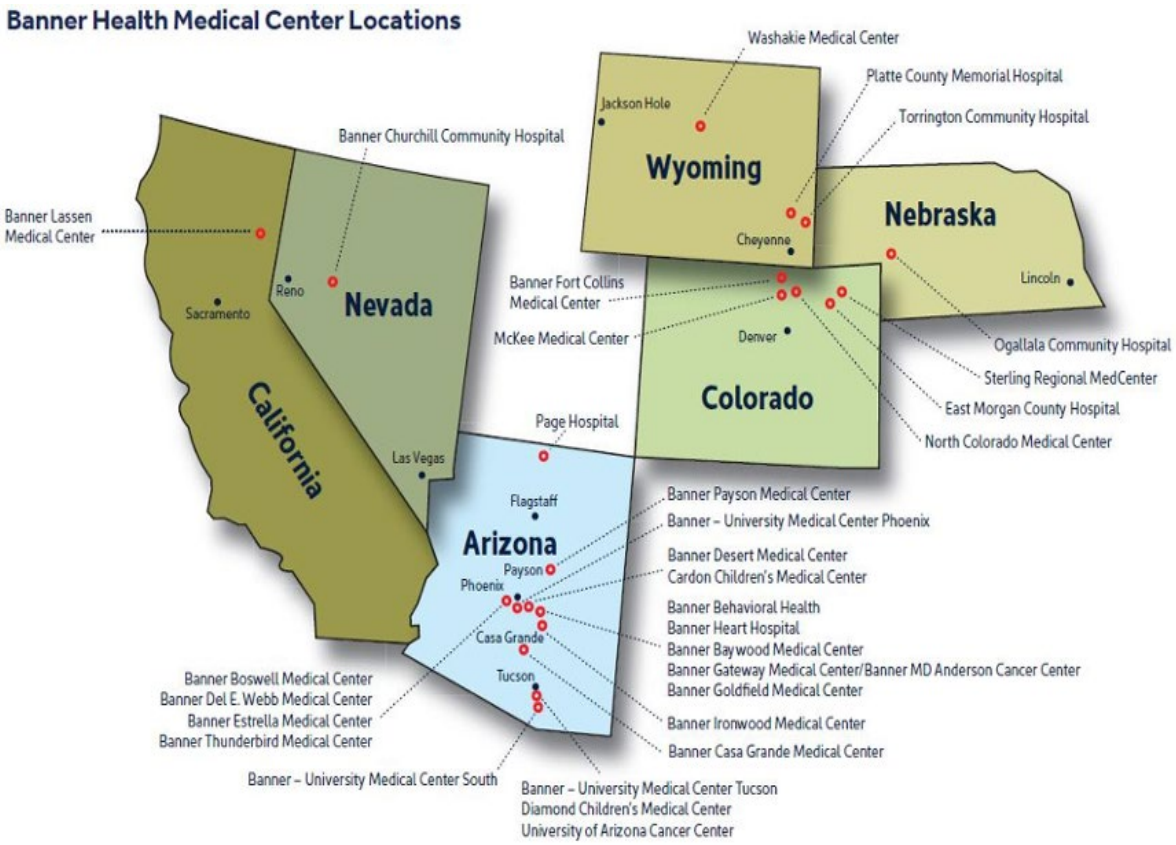
Session Outline

- Discuss the Roll-out and Implementation of Radiation Dose Tracking Software across Banner Health

- Challenges & Solutions

- Lessons Learned

Mission: “Making health care easier, so life can be better.”

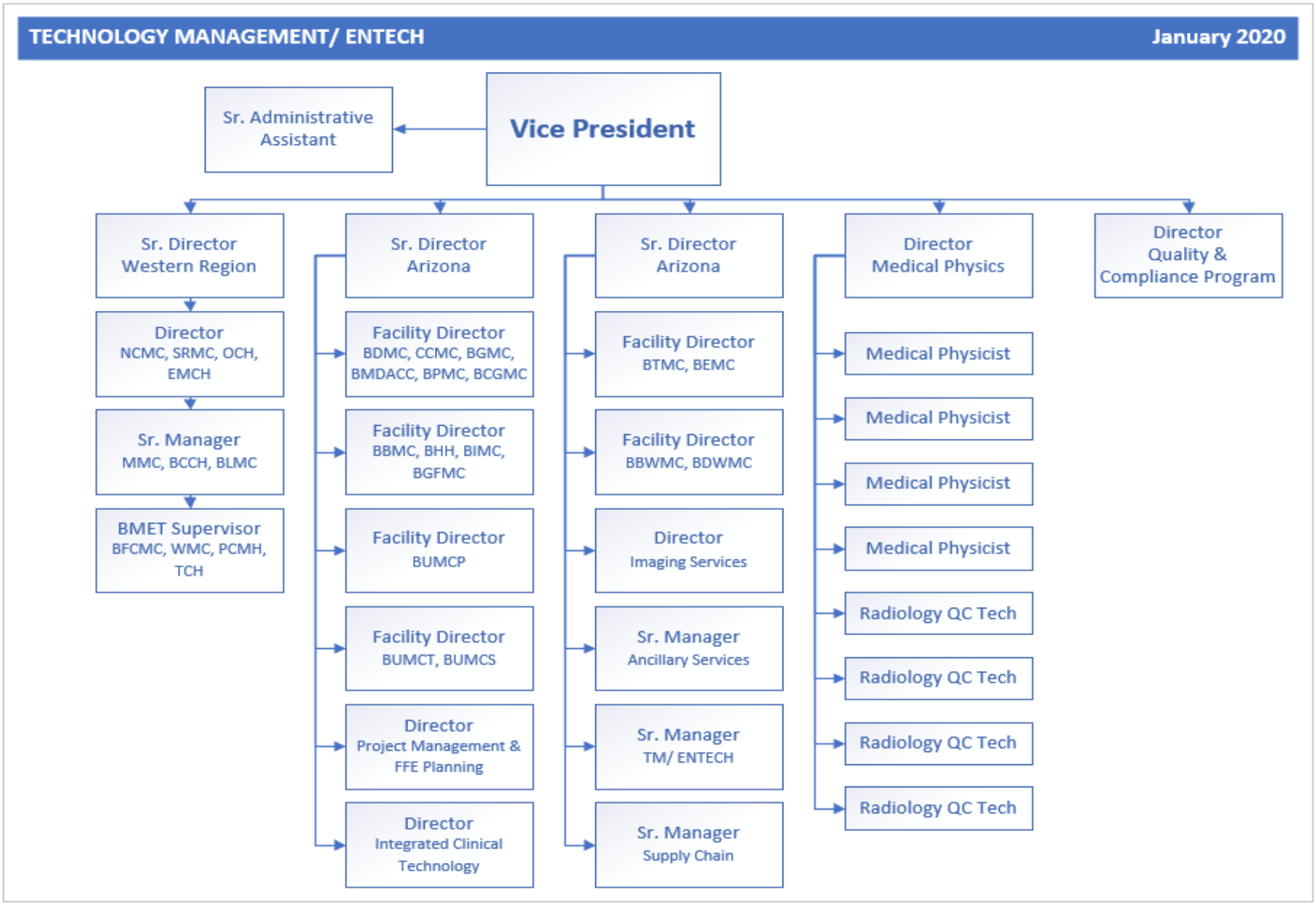


Banner Health is a non-profit health system in the United States, based in Phoenix, Arizona.

It operates 28 hospitals and several specialized facilities across 6 states.

The health system is the largest employer in Arizona and one of the largest in the United States with over 50,000 employees.

Mission: “Making health care easier, so life can be better.”



Challenge

California CT Dose Law

"Commencing July 1, 2012, subject to subdivision (e), a person that uses a computed tomography (CT) X-ray system for human use shall record the dose of radiation on every diagnostic CT study produced during a CT examination in the patient's record, as defined in Section 123105."

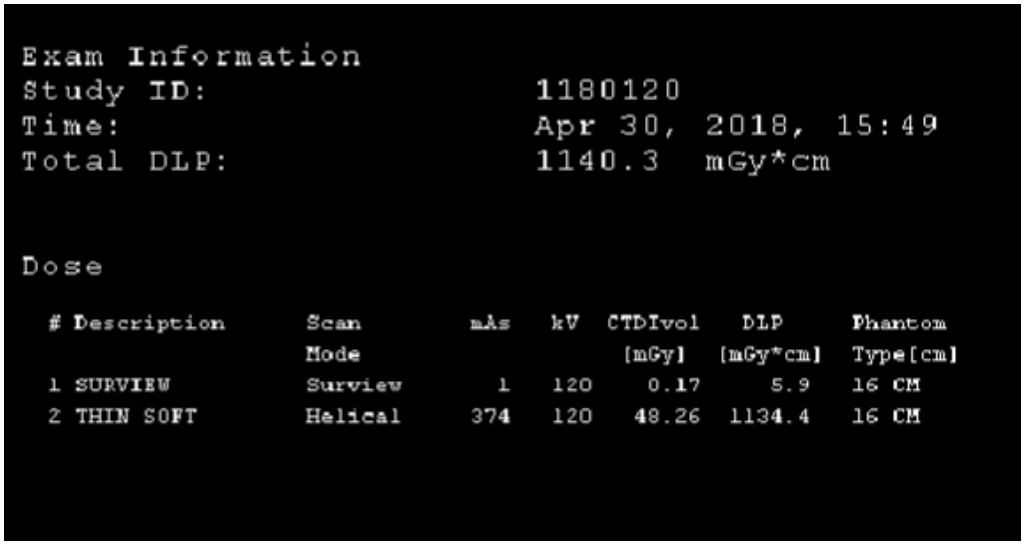
Challenge

Joint Commission implemented the new diagnostic imaging standard (2015)

- Track radiation doses
- Compare to benchmarks
- Store in medical record

Manual approach not viable

- Radiology dictated into Powerscribe



Exam Information

Study ID:	1180120
Time:	Apr 30, 2018, 15:49
Total DLP:	1140.3 mGy*cm

Dose

#	Description	Scan Mode	mAs	kV	CTDIvol [mGy]	DLP [mGy*cm]	Phantom Type[cm]
1	SURVIEW	Surviev	1	120	0.17	5.9	16 CM
2	THIN SOFT	Helical	374	120	48.26	1134.4	16 CM

Solution: Radiation Dose Tracking Software

Radiation dose tracking software purchased by Banner: Radimetrics

Server based

- Auto-imports dose from modality
- Sends dose report to Powerscribe, directly to rad report

Currently CT only

CT Abdomen W/Contrast

Start of Report

HISTORY: Pain

COMPARISON: None

FINDINGS: No abnormalities seen.

IMPRESSION:
Normal exam.

Radimetrics Dose Report:

SSDE: 18.3 mGy CTDIvol Body: 5.1 mGy

End of Report

The workstation used in generating this report was [redacted].

***** Final Report *****

Process overview

- Radimetrics specifics depending on study volume
  - Servers built with appropriate resources (storage space, CPUs. Etc.) to be able to manage the study data
- Remote hospitals away from main server are equipped with a local “pre-processor” server to eliminate any latency with Radiologists reports
- Engage the site to identify key users for implementation
  - CT supervisor, CT lead technologist, MI director, RSO, etc..
- Engage the site to standardize protocol names on all scanners, configure protocols to auto-send to Radimetrics
- Configure all CT scanners with DICOM destinations, scanner station names for mapping to facility
- Configure PowerScribe interface to include new site

Process overview

- Update cloverleaf interface (interface engine) to include new facility messages
  - End result being that a patient with a CT exam is created in Radimetrics automatically when Radiology order is entered into Cerner
- ACR triad server configuration and mapping (to send dose to ACR for dose registry)
- Validate that each additional scanners are sending the needed DICOM information to Radimetrics
  - e.g. Dose sheet, scouts, acquisitions
- Protocol mapping- Map Device protocols to Master protocols (mapping to one RPID for one protocol for all facilities)

Challenge #2: Lots of Variability

Each site has unique protocols & naming conventions

Radiation doses vary

- Across sites
- Within protocols

Chest CT Without Contrast Protocol Names (n=11):	
Chest W/O Contrast	Chest Without Contrast HCT 5mm
ROUTINE CHEST WITHOUT	Chest W/O Con 3mm
CHEST ROUTINE WITHOUT	Chest W/O Con 3mm(1mmx32)
CHEST RTN W/O/Thorax	CHEST W/O (0.5mm x 32)
CHEST W/O	CHEST W/O SMALL/MED PT
CHEST_WO	

Solution: Standardization

Create standard protocol lexicon

- Based on RadLex Playbook

Map each protocol to a given RPID (Radlex Playbook ID)

Allow each site to have some flexibility in naming protocols

RPID	Letter Code	Short Description	Long Description
RPID2	CTABCA	CT Abd Angio w/wo	CT Abdomen Angio w and wo IV Contrast
RPID3	CTABU	CT Abd wo	CT Abdomen wo IV Contrast
RPID4	CTABC	CT Abd w/wo	CT Abdomen w and wo IV Contrast
RPID5	CTABE	CT Abd w	CT Abdomen w IV Contrast
RPID6	CTCHCA	CT Chest Angio w/wo	CT Chest Angio w and wo IV Contrast
RPID7	CTHDCA	CT Head Angio w/wo	CT Head Angio w and wo IV Contrast
RPID10	CTLECA	CT Leg Angio w/wo	CT Lower Extremity Angio w and wo IV Contrast
RPID11	CTNKCA	CT Neck Angio w/wo	CT Neck Angio w and wo IV Contrast
RPID12	CTPLCA	CT Pelv Angio w/wo	CT Pelvis Angio w and wo IV Contrast
RPID14	CTUECA	CT Arm Angio w/wo	CT Upper Extremity Angio w and wo IV Contrast
RPID16	CTCHU	CT Chest wo	CT Chest wo IV Contrast
RPID17	CTCHC	CT Chest w/wo	CT Chest w and wo IV Contrast
RPID18	CTCHE	CT Chest w	CT Chest w IV Contrast
RPID19	CTCSC	CT C-Spine w/wo	CT Cervical Spine w and wo IV Contrast
RPID20	CTCSE	CT C-Spine w	CT Cervical Spine w IV Contrast
RPID21	CTCSU	CT C-Spine wo	CT Cervical Spine wo IV Contrast
RPID22	CTHDU	CT Head wo	CT Head wo IV Contrast
RPID23	CTHDC	CT Head w/wo	CT Head w and wo IV Contrast
RPID24	CTHDE	CT Head w	CT Head w IV Contrast
RPID31	CTLSU	CT L-Spine wo	CT Lumbar Spine wo IV Contrast
RPID32	CTLSC	CT L-Spine w/wo	CT Lumbar Spine w and wo IV Contrast
RPID33	CTLSE	CT L-Spine w	CT Lumbar Spine w IV Contrast

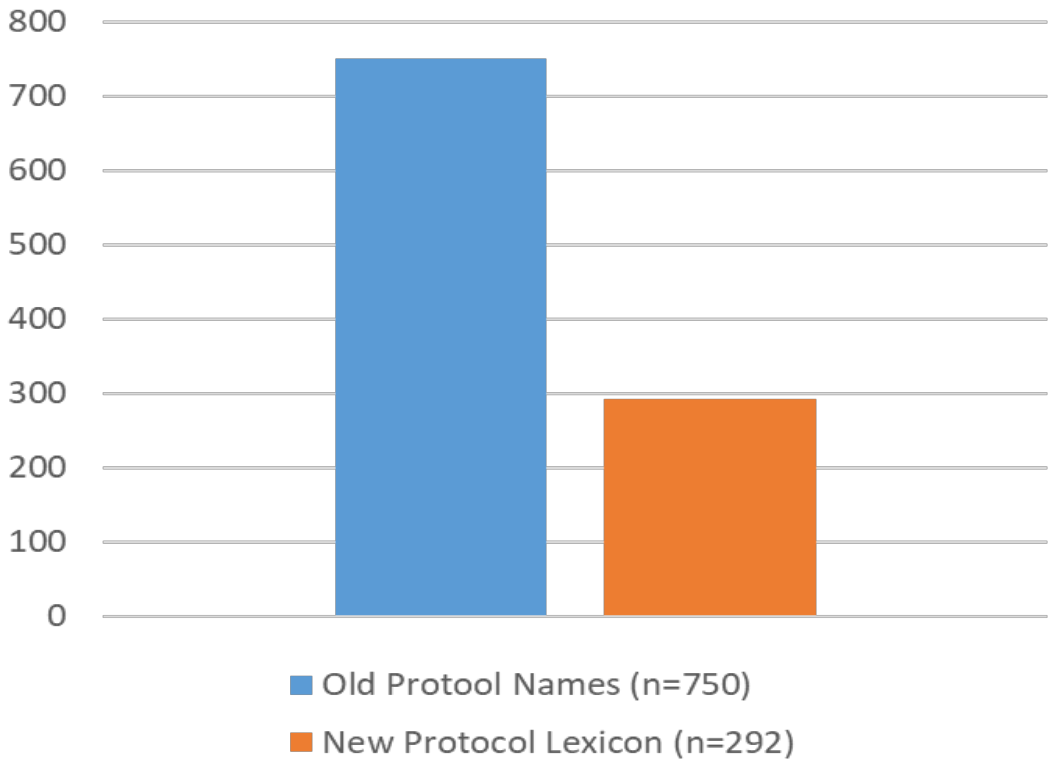
Radlex

- Radlex: a Radiology lexicon produced by RSNA
- RSNA definition: “a comprehensive set of radiology terms for use in radiology reporting, decision support, data mining, data registries, education, and research.”
- Reduce variation in protocoling among other things
- Enhances information sharing and analysis

Solution: Standardization

End Result

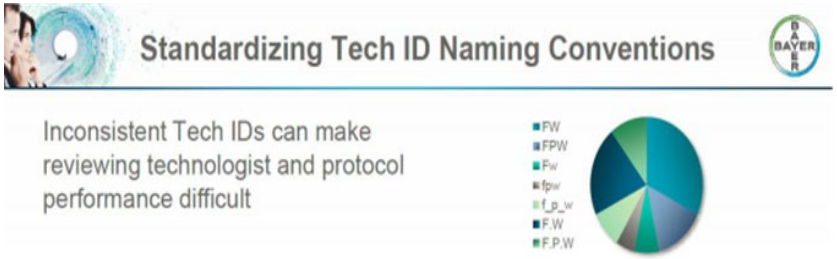
- ~60% decrease in variation of protocol names



Solution: Standardization

Standardize Equipment Name Protocol

Standardize Tech ID Naming



Station Name	Device	Manufacturer	Institution	Serial No.
BDMC_ED_CT2	Aquilion	TOSHIBA	BANNER DESERT MEDICAL C	[redacted]
BBMC_MI_CT2	Aquilion	TOSHIBA	BANNER BAYWOOD MED CTI	
Unknown Equipment	Unknown Model	FUJIFILM Medical Systems US	Unknown Institution	
ID_STATION	Aquilion	TOSHIBA	BANNER-UMC PHOENIX CT2	
BGFMCCT1	LightSpeed Pro 16	GE MEDICAL SYSTEMS	Banner Goldfield Medical Cen	
ID_STATION	Aquilion	TOSHIBA	BANNER BAYWOOD MED CTI	
GECT	LightSpeed VCT	GE MEDICAL SYSTEMS	Banner MD Anderson	
CT39076	Emotion 16	SIEMENS	BCGMC	
BGFMC_MI_CT1	LightSpeed Pro 16	GE MEDICAL SYSTEMS	Banner Goldfield Medical Cen	
ID_STATION	Aquilion	TOSHIBA	BANNER GATEWAY MEDICAL	
ID_STATION	Aquilion	TOSHIBA	BANNER DESERT CT4	
WEBPH64CT	Brilliance 64	Philips	BANNER DEL WEBB CT1	
bamcct	LightSpeed Ultra	GE MEDICAL SYSTEMS	Banner Health Center Peoria	
BBMC_MI_CT1	Aquilion	TOSHIBA	BANNER BAYWOOD 32	
CTAWP64508	SOMATOM Definition AS	SIEMENS	CGRMC	
BDWMC_OP_CT1	Sensation 64	SIEMENS	BANNER DEL WEBB OUTPAT	
CT50692	Sensation 16	SIEMENS	Banner Boswell Medical Imagi	
WEB_NO_CT1	Sensation 64	SIEMENS	BANNER DEL WEBB OUTPAT	
amcct	LightSpeed16	GE MEDICAL SYSTEMS	BANNER HEALTH CENTER	
BGMC	LightSpeed VCT	GE MEDICAL SYSTEMS	Banner MD Anderson Imaging	
ID_STATION	Aquilion	TOSHIBA	BANNER-UMC PHOENIX CT1	
MAIN 32 SCON	Aquilion	TOSHIBA	BANNER BAYWOOD 32	

Challenge #3: How to Organize

Involves multiple specialties:

- Radiologists
- Radiation Safety Officer
- Physicists
- Medical Imaging Managers
- CT Technologists
- Information Technology, includes TM/ ENTECH
- Administrative support

Solution: Create a System

Define Goals:

1. Optimize radiation doses
2. Decrease variability in radiation doses within protocols

Define Implementation:

Governance group

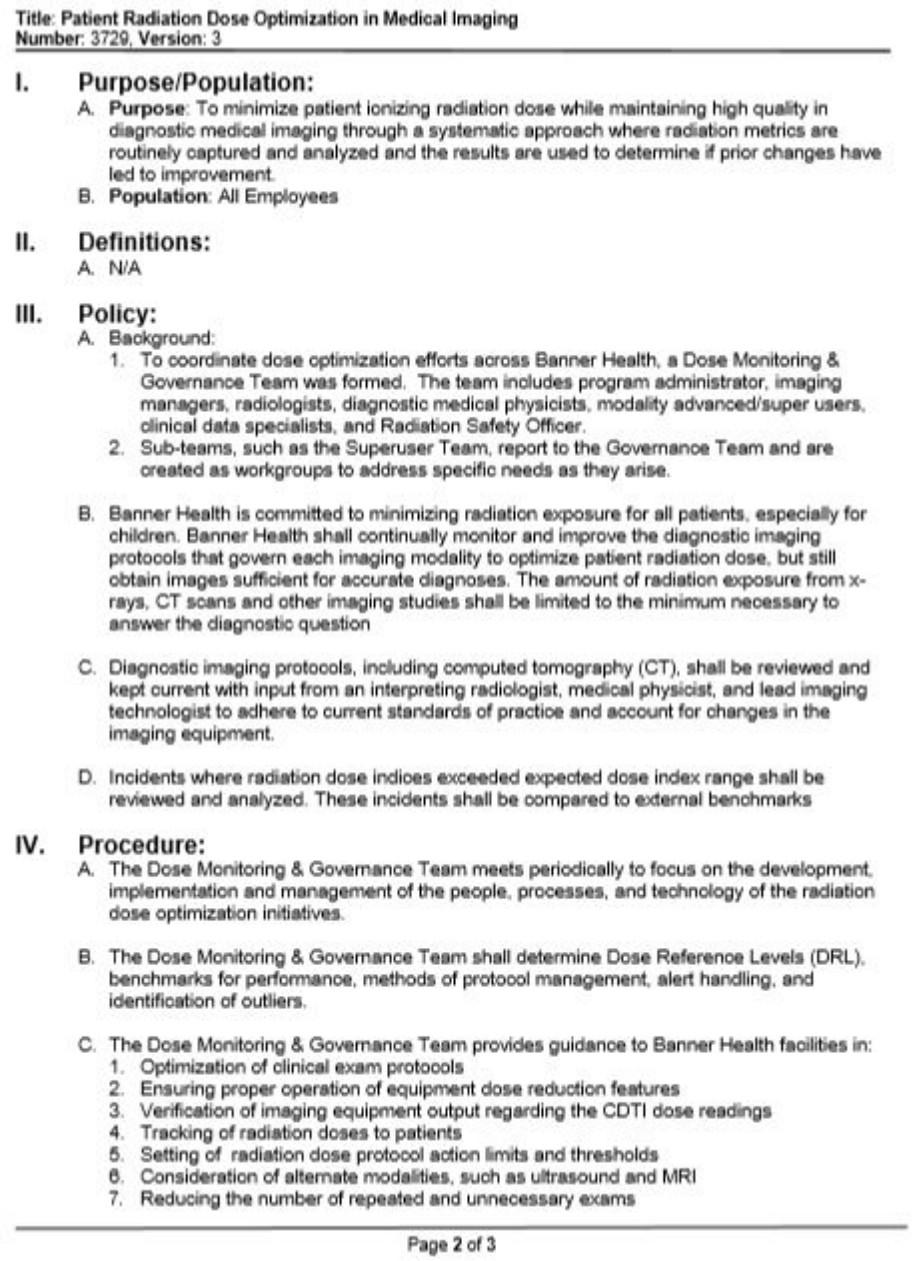
- Set standards/ policies

Users group

- Empower sites to make changes locally

Solution: Governance Group

- Create policies
- Define dose benchmarks
- Define system-wide projects
- Discuss issues pertaining to Radimetrics
- Enterprise RSO also participates in the Super Users group



Title: Patient Radiation Dose Optimization in Medical Imaging
Number: 3729, Version: 3

I. Purpose/Population:

A. **Purpose**: To minimize patient ionizing radiation dose while maintaining high quality in diagnostic medical imaging through a systematic approach where radiation metrics are routinely captured and analyzed and the results are used to determine if prior changes have led to improvement.
B. **Population**: All Employees

II. Definitions:

A. N/A

III. Policy:

A. Background:
1. To coordinate dose optimization efforts across Banner Health, a Dose Monitoring & Governance Team was formed. The team includes program administrator, imaging managers, radiologists, diagnostic medical physicists, modality advanced/super users, clinical data specialists, and Radiation Safety Officer.
2. Sub-teams, such as the Superuser Team, report to the Governance Team and are created as workgroups to address specific needs as they arise.

B. Banner Health is committed to minimizing radiation exposure for all patients, especially for children. Banner Health shall continually monitor and improve the diagnostic imaging protocols that govern each imaging modality to optimize patient radiation dose, but still obtain images sufficient for accurate diagnoses. The amount of radiation exposure from x-rays, CT scans and other imaging studies shall be limited to the minimum necessary to answer the diagnostic question

C. Diagnostic imaging protocols, including computed tomography (CT), shall be reviewed and kept current with input from an interpreting radiologist, medical physicist, and lead imaging technologist to adhere to current standards of practice and account for changes in the imaging equipment.

D. Incidents where radiation dose indices exceeded expected dose index range shall be reviewed and analyzed. These incidents shall be compared to external benchmarks

IV. Procedure:

A. The Dose Monitoring & Governance Team meets periodically to focus on the development, implementation and management of the people, processes, and technology of the radiation dose optimization initiatives.

B. The Dose Monitoring & Governance Team shall determine Dose Reference Levels (DRL), benchmarks for performance, methods of protocol management, alert handling, and identification of outliers.

C. The Dose Monitoring & Governance Team provides guidance to Banner Health facilities in:
1. Optimization of clinical exam protocols
2. Ensuring proper operation of equipment dose reduction features
3. Verification of imaging equipment output regarding the CDTI dose readings
4. Tracking of radiation doses to patients
5. Setting of radiation dose protocol action limits and thresholds
6. Consideration of alternate modalities, such as ultrasound and MRI
7. Reducing the number of repeated and unnecessary exams

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Solution: Governance Group

- Policy:
  - Background:
    - To coordinate dose optimization efforts across BH, a Dose Monitoring & Governance team was formed. The team includes program administrator, imaging managers, radiologists, diagnostic medical physicists, modality advanced/ super users, clinical data specialists, and radiation safety officer.
    - Sub-teams, such as the super user team report to the governance team and are created as workgroups to address specific needs as they arise.

Solution: Users Group

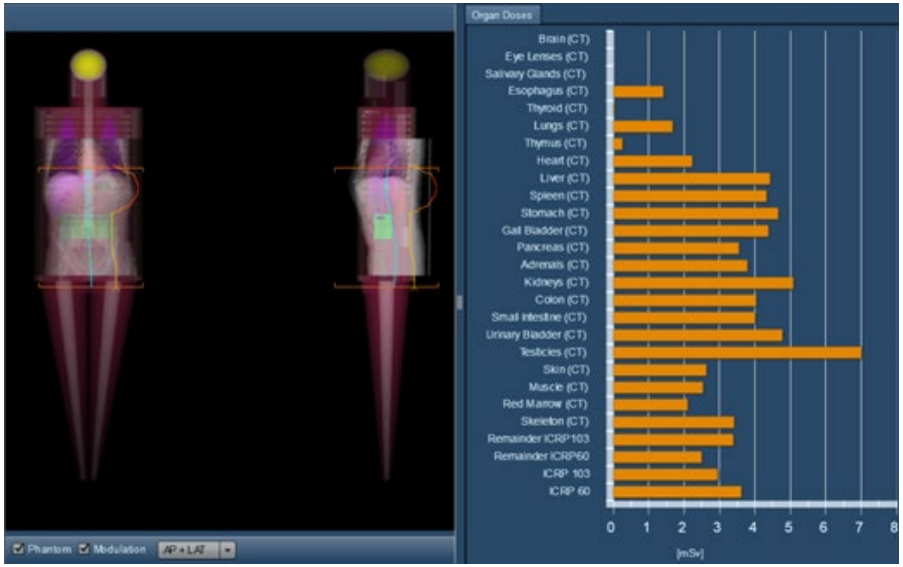
- Led by Radiation Safety Officer
- Each site designates a super-user for Radimetrics
- Communicate changes/ updates
- Feedback regarding processes/ policies/ procedures

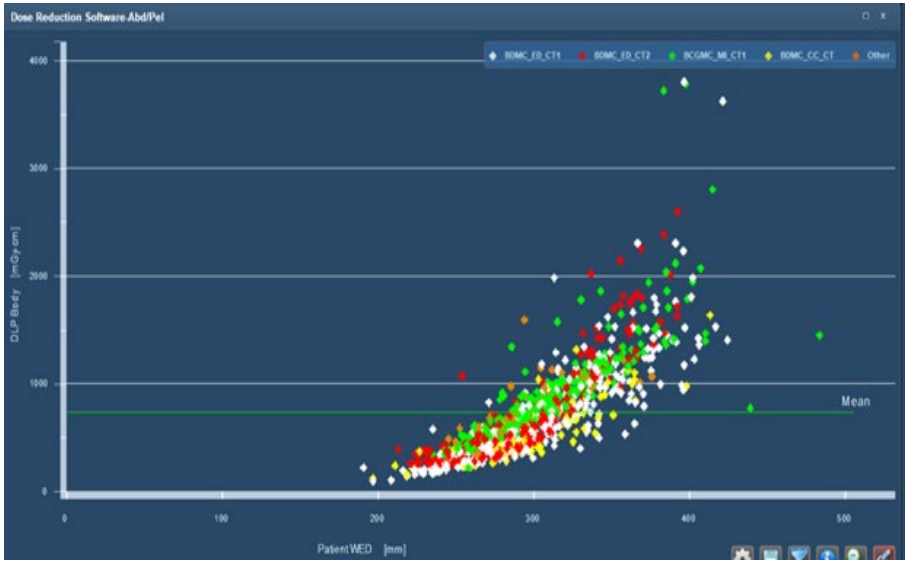
Who We Report To:

- Medical Imaging Clinical Consensus Group
- Health Care Facilities
- Banner Senior Management

Challenge #4: Lots of data

Radimetrics supplies many types of radiation dose data





Solution: Be Selective

Initially we chose to track:

- CTDI vol = Volume CT Dose Index
- DLP = Dose Length Product

Differentiate between reconstruction method:

- Filtered Back Projection
- Iterative

Solution: Be Selective

Volume CT Dose Index (CTDI vol)

- Metric reported by CTs that provides information of dose to a phantom (either a 32 cm diameter CT dose phantom or a 16 cm diameter CT dose phantom)
- 32 cm diameter phantom representing an abdomen and the 16 cm diameter phantom representing the head of a adult patient
- Not patient dose but can be considered as a measure of the output of the scanner

Dose Length Product (DLP)

- CTDI vol times the scan length

Challenge #5: How to Disseminate Results

What to do with the data?

How to act on the data

Solution: Creating Actionable Reports

Site Specific Reports

- Generated quarterly for each site
- Contains site specific recommendations
- Generated by the enterprise Radiation Safety Officer

Solution: Creating Actionable Reports

Banner Health

5/5/2018

COMPUTED TOMOGRAPHY DOSE REDUCTION MONTHLY REPORT

Banner Del Webb Medical Center

CT Scanner(s): BDWMC_ED_CT

CT Scanners using Iterative Reconstruction image processing

The purpose of this report is to provide CT dose information and highlight opportunities for the Medical Center Radiation Dose Reduction Committee to reduce patient dose. As the Dose Reduction Committee meets periodically to review imaging protocols and radiation dose, this report compares the previous month's Computed Tomography Dose Index (CTDIvol) and Dose-Length Product (DLP) values to similar CT scanner models within Banner Health, other CT scanners within Banner Health, and National Benchmarks such as the American College of Radiology Dose Index Registry (DIR).

The Medical Center Radiation Dose Reduction Committee should be composed of the radiology administrator or center manager, the chief or supervising radiologist, the diagnostic medical physicist, and the chief CT technologist. The diagnostic medical physicist should take the lead on the technical aspects. The supervising radiologist approves protocol changes as well as needed changes to policies and procedures. The chief CT technologist is important to address procedural and clinical practice changes. The committee reviews protocols, image quality and doses compared to benchmarks, then recommend the specific protocol changes, sets dose action limits, verifies indicated scanner doses, trains other staff, etc.

This report suggests three prioritized opportunities to reduce CT radiation dose, presents CTDI and DLP data for CT found within the medical center, and presents technique factors that should be reviewed by the committee to discover opporutinites for protocol adjustment.

This report also is useful to demonstrate compliance with The Joint Commission requirements:

PC.01.02.15 EP5 Document the CT radiation dose index in a retrievable format
PC.01.02.15 EP10 Verify correct patient CT protocol and CT scan parameters
PC.01.03.01 EP25 Establish CT protocols including indication, contrast, age, size, and expected dose index range.
PC.01.03.01 EP26 Review CT protocols with input from a radiologist, medical physicist, and technologist.

For Diagnostic Medical Physicist support, please contact Uday Rao at Uday.Rao@bannerhealth.com

Potential Opportunites for Dose Reduction:

Among other opportunities, these should be reviewed by the Radiation Dose Reduction Committee (DRC)

CT	Protocol Set	Observation
BDWMC_ED_CT SOMATOM Definition	Adult CT Abdomen and Adult CT Sinus	DLP greater the benchmark, although CTDI meets benchmark
BDWMC_ED_CT SOMATOM Definition	All	mAs higher the average mAs for other Iterative Reconstruction CTs
BDWMC_ED_CT SOMATOM Definition	Pediatric Protocols	Review Pediatric Protocols to ensure correct mapping and reporting to Radimetric

[redacted]

Paul Hanny, Ph.D., DABR

Corporate Radiation Safety Officer

ADULT CT DOSE for the previous month

Medical Center CTs are grouped according to model and compared to other Banner Health CTs of the same model. They are also compared to all Banner Health CTs using Iterative Reconstruction techniques for image formation. The benchmarks are from the American College of Radiology Dose Index Registry (ACR DIR) and are compared at the 75th percentile.

Adult	November, 2019		Number of exams	CTDIvol (mGy)		Benchmark		Is CTDI less than Benchmark?	DLP (mGy·cm)		Benchmark		Is DLP less than Benchmark?
				mean	75th	mean	75th		mean	75th	mean	75th	
Head	BUMCP_ED_CT	SOMATOM Force	699	58.5	58.7	54	61	Yes	1097	1141	857	1010	No
						54	61	-			857	1010	-
	Banner SOMATOM Force		1333	54.4	58.5	54	61	Yes	1036	1106	857	1010	No
	Banner CTs (Iterative Recon)		7752	51.5	57.5	54	61	Yes	956	1079	857	1010	Yes
Chest	BUMCP_ED_CT	SOMATOM Force	242	5.0	6.2	10	15	Yes	179	225	660	1029	Yes
						10	15	-			660	1029	-
	Banner SOMATOM Force		522	7.5	10.1	10	15	Yes	270	365	660	1029	Yes
	Banner CTs (Iterative Recon)		4148	9.7	12.5	10	15	Yes	351	457	660	1029	Yes
Abdomen/Pelvis	BUMCP_ED_CT	SOMATOM Force	863	12.0	14.8	14	18	Yes	619	788	476	633	Yes
						14	18	-			476	633	-
	Banner SOMATOM Force		1460	11.7	14.5	14	18	Yes	607	767	476	633	Yes
	Banner CTs (Iterative Recon)		12005	11.4	14.2	14	18	Yes	556	716	476	633	Yes
Sinus	BUMCP_ED_CT	SOMATOM Force	53	10.5	10.5	24	33	Yes	221	236	408	649	Yes
						24	33	-			408	649	-
	Banner SOMATOM Force		79	13.9	20.5	24	33	Yes	299	427	408	649	Yes
	Banner CTs (Iterative Recon)		580	23.8	26.625	24	33	Yes	489	574	408	649	Yes
Neck	BUMCP_ED_CT	SOMATOM Force	43	12.3	13.9	15	20	Yes	374	444	422	589	Yes
						15	20	-			422	589	-
	Banner SOMATOM Force		63	10.8	13.1	15	20	Yes	352	397	422	589	Yes
	Banner CTs (Iterative Recon)		467	10.9	12.8	15	20	Yes	327	408	422	589	Yes

Banner SOMATOM Force CT Scanners:

BDMC_ED_CT1	BANNER DESERT MEDICAL CENTER
BUMCP_ED_CT	BANNER UNIVERSITY MEDICAL CENTER-PHOENIX

Solution: Creating Actionable Reports

Adult	November, 2019		Number of exams	CTDIvol (mGy)				Is CTDI less than Benchmark?	DLP (mGy·cm)				Is DLP less than Benchmark?
						Benchmark					Benchmark		
				mean	75th	mean	75th		mean	75th	mean	75th	
Head	BUMCP_ED_CT	SOMATOM Force	699	58.5	58.7	54	61	Yes	1097	1141	857	1010	No
						54	61	-			857	1010	-
	Banner SOMATOM Force		1333	54.4	58.5	54	61	Yes	1036	1106	857	1010	No
	Banner CTs (Iterative Recon)		7752	51.5	57.5	54	61	Yes	956	1079	857	1010	Yes

Solution: Creating Actionable Reports

ADULT CT TECHNIQUES for the previous month

A review of the techniques used in Adult CT scans may highlight opportunities for optimizing image quality while reducing dose. Technique factors much higher or lower than similar scanners should be reviewed for appropriateness. mAs and Rotation Time are highlighted if above the average for each protocol group. Collimationand Pitch values are highlighted if below the average for each protocol group.

Adult	November 2019		Number of exams	Mean mAs	Min mAs	Max mAs	Rotation Time	Collimation	Pitch
Head	BUMCP_ED_CT	SOMATOM Force	699	208.4	202.6	222.0	0.940	38.4	0.599
	Banner SOMATOM Force		1333	202.1	198.3	211.5	0.948	44.1	0.592
	Banner CTs (Iterative Recon)		7809	213.6	200.2	215.7	0.810	32.1	0.725
Chest	BUMCP_ED_CT	SOMATOM Force	242		166.4	371.7	0.253	57.6	2.055
	Banner SOMATOM Force		522	210.2	199.8	437.5	0.284	57.6	1.876
	Banner CTs (Iterative Recon)		4165	140.6	114.3	219.4	0.445	42.8	1.250
Abdomen	BUMCP_ED_CT	SOMATOM Force	863	136.0	63.2	266.7	0.497	46.6	0.597
				-	-	-	-	-	-
	Banner SOMATOM Force		1460	130.0	63.4	271.8	0.498	51.1	0.600
	Banner CTs (Iterative Recon)		12235	119.9	75.0	167.3	0.509	41.4	0.819
Sinus	BUMCP_ED_CT	SOMATOM Force	53	64.0	61.9	67.4	0.991	57.2	0.764
	Banner SOMATOM Force		79	81.3	79.7	83.4	0.994	57.4	0.776
	Banner CTs (Iterative Recon)		584	90.2	85.3	100.9	0.602	38.3	0.706
Neck	BUMCP_ED_CT	SOMATOM Force	43	142.3	79.2	219.3	1.000	57.6	0.800
				-	-	-	-	-	-
	Banner SOMATOM Force		63	130.4	77.4	207.9	1.000	57.6	0.800
	Banner CTs (Iterative Recon)		432	125.6	78.1	207.1	0.713	36.7	0.882

Solution: Creating Actionable Reports

Adult	November 2019		Number of exams	Mean mAs	Min mAs	Max mAs	Rotation Time	Collimation	Pitch
Head	BUMCP_ED_CT	SOMATOM Force	699	208.4	202.6	222.0	0.940	38.4	0.599
	Banner SOMATOM Force		1333	202.1	198.3	211.5	0.948	44.1	0.592
	Banner CTs (Iterative Recon)		7809	213.6	200.2	215.7	0.810	32.1	0.725

Solution: Creating Actionable Reports

Protocol Names Used for Adult CT data for BUMCP_ED_CT SOMATOM Force

Head	Number of exams	Mean CTDIvol (mGy)	Mean DLP (mGy·cm)	Chest	Number of exams	Mean CTDIvol (mGy)	Mean DLP (mGy·cm)
CT_HEAD_XC_TRAUMA_WO	690	58.4	1097	CT_DE_PE_ANGIO	85	6.8	251
CT_HEAD_XC_WO_W	5	58.3	1124	CT_CHEST_ANGIO_PE_W_FLASH	85	4.0	137
CT_HEAD_WO_WITH	4	59.8	1035	CT_CHEST_W_FLASH	18	4.3	156
				CT_CHEST_WO_FLASH	54	3.9	139

Abdomen/Pelvis	Number of exams	Mean CTDIvol (mGy)	Mean DLP (mGy·cm)	Sinus	Number of exams	Mean CTDIvol (mGy)	Mean DLP (mGy·cm)
DE_ABD_PEL_WITH	247	11.5	604	CT_MAXILLOFACIAL_WO	23	10.5	221
DE_ABD_PEL_WO	145	11.9	622	CT_MAXILLOFACIAL_W	30	10.5	221
CT_ABD_W_WO_LIVER	7	6.8	282				
DE_PEL_WITH	7	13.6	547				
CT_ABD_PEL_W	158	13.8	719				
CT_PEL_WO	9	7.3	241				

Solution: Creating Actionable Reports

Case Example: BCGMC Chest

Banner Health

12/3/2018

COMPUTED TOMOGRAPHY DOSE REDUCTION MONTHLY REPORT

BANNER CASA GRANDE MEDICAL CENTER

CT Scanner(s): BCGMC_MI_CT1 BCGMC_DRIC_CT

CT Scanners using Filtered Backprojection image processing

The purpose of this report is to provide CT dose information and highlight opportunities for the Medical Center Radiation Dose Reduction Committee to reduce patient dose. As the Dose Reduction Committee meets periodically to review imaging protocols and radiation dose, this report compares the previous month's Computed Tomography Dose Index (CTDIvol) and Dose-Length Product (DLP) values to similar CT scanner models within Banner Health, other CT scanners within Banner Health, and National Benchmarks such as the American College of Radiology Dose Index Registry (DIR).

The Medical Center Radiation Dose Reduction Committee should be composed of the radiology administrator or center manager, the chief or supervising radiologist, the diagnostic medical physicist, and the chief CT technologist. The diagnostic medical physicist should take the lead on the technical aspects. The supervising radiologist approves protocol changes as well as needed changes to policies and procedures. The chief CT technologist is important to address procedural and clinical practice changes. The committee reviews protocols, image quality and doses compared to benchmarks, then recommend the specific protocol changes, sets dose action limits, verifies indicated scanner doses, trains other staff, etc.

This report suggests three prioritized opportunities to reduce CT radiation dose, presents CTDI and DLP data for CT found within the medical center, and presents technique factors that should be reviewed by the committee to discover opporutinites for protocol adjustment.

This report also is useful to demonstrate compliance with The Joint Commission requirements:

PC.01.02.15 EP5 Document the CT radiation dose index in a retrievable format
PC.01.02.15 EP10 Verify correct patient CT protocol and CT scan parameters
PC.01.03.01 EP25 Establish CT protocols including indication, contrast, age, size, and expected dose index range.
PC.01.03.01 EP26 Review CT protocols with input from a radiologist, medical physicist, and technologist.

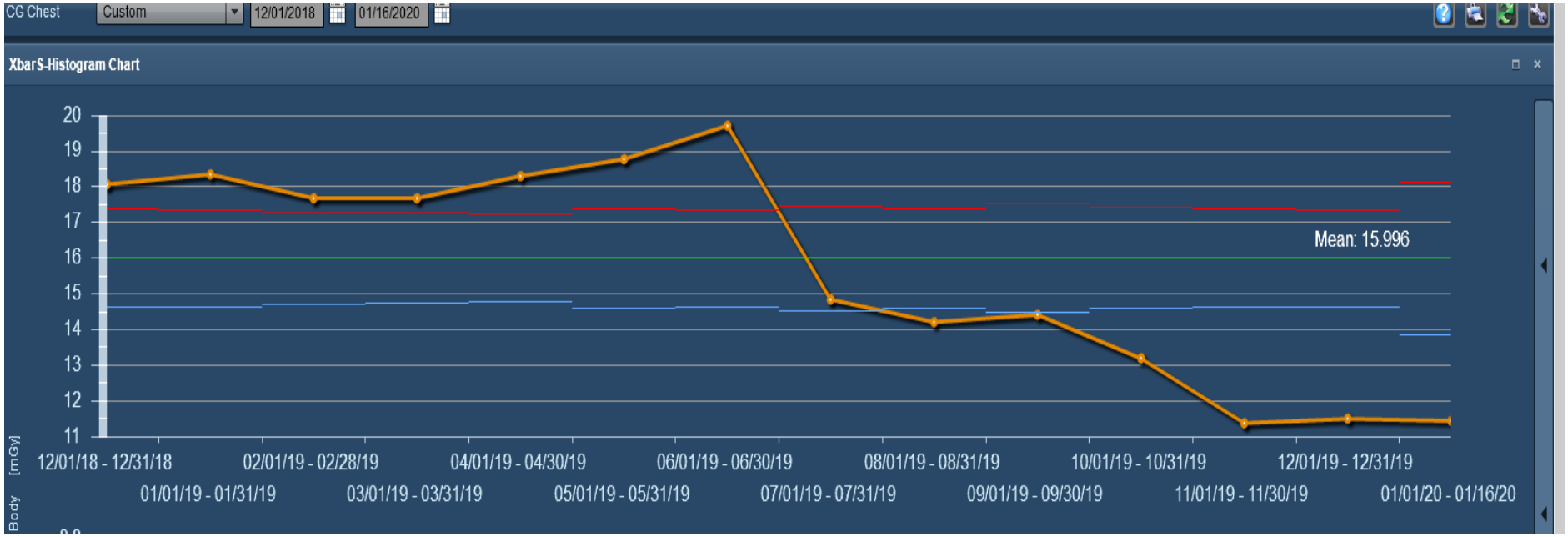
For Diagnostic Medical Physicist support, please contact Uday Rao at Uday.Rao@bannerhealth.com

Potential Opportunites for Dose Reduction:

Among other opportunities, these should be reviewed by the Radiation Dose Reduction Committee (DRC)

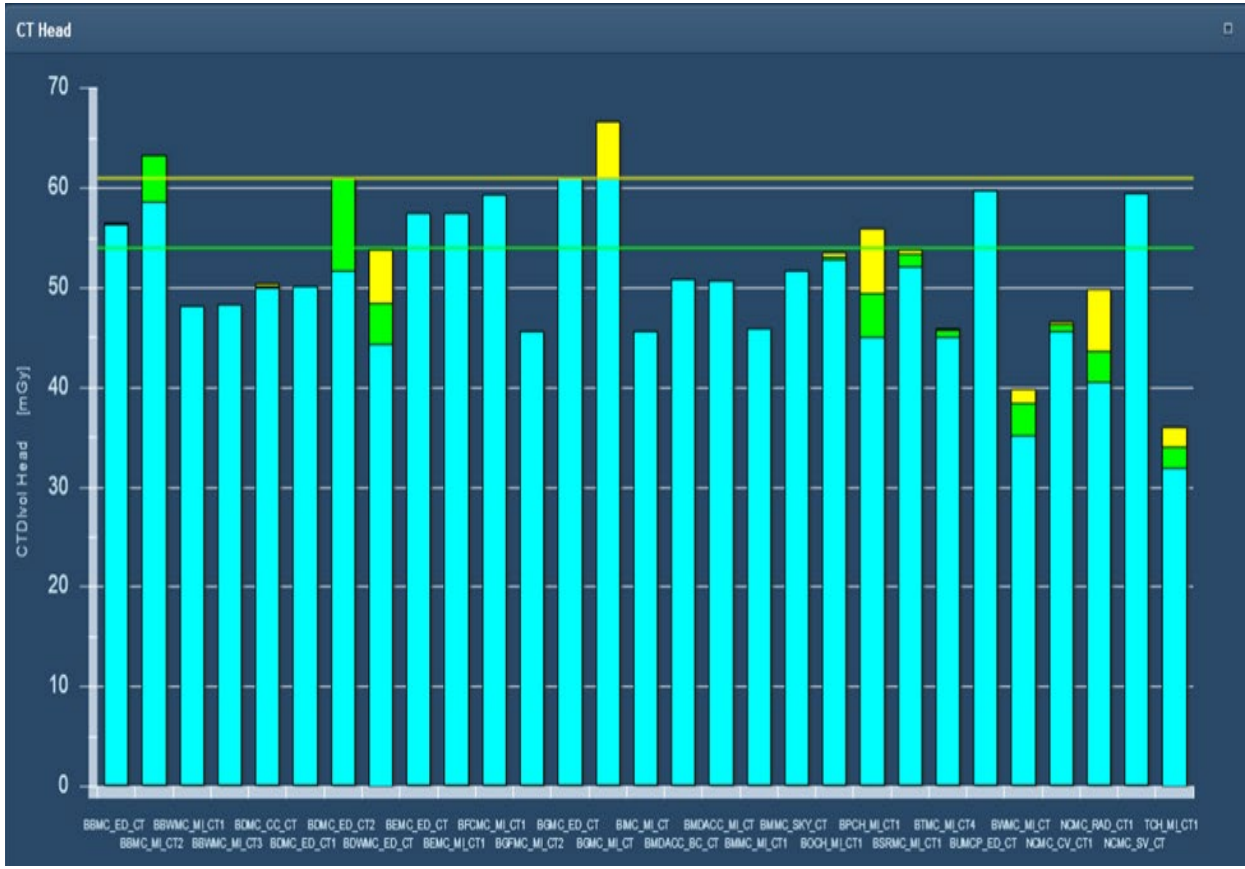
CT	Protocol Set	Observation
BCGMC_MI_CT1 SOMATOM Definition	Adult CT Chest	CTDIvol greater than benchmark
BCGMC_MI_CT1 SOMATOM Definition	Adult CT Abdomen/Pelvis	CTDIvol and DLP greater than benchmark

Case Example: BCGMC



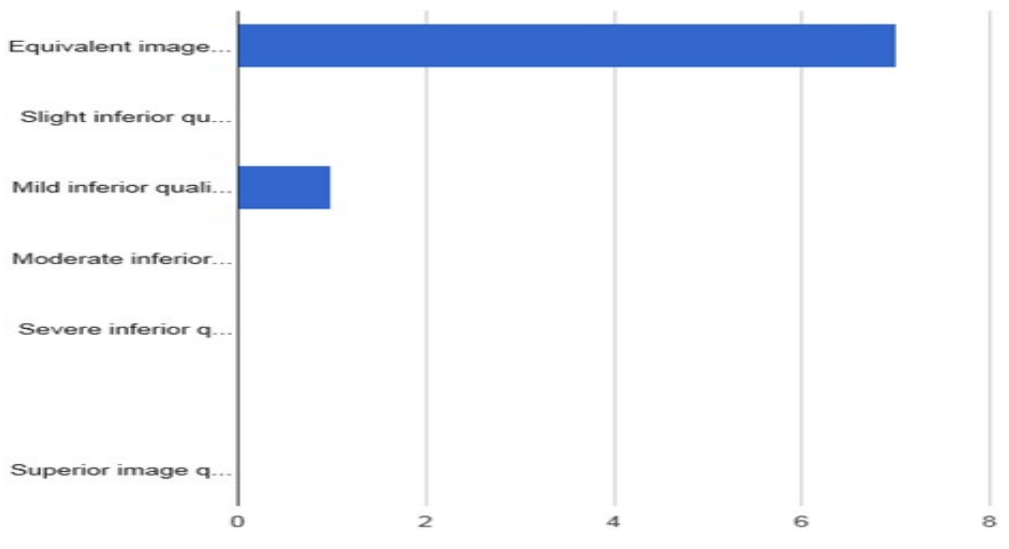
Case Example: Head CT Dose

1. Created benchmarks based on published data
2. Identified sites with doses consistently above target
3. Reach out to sites and ask about implementing dose reduction
   - Assess baseline image quality

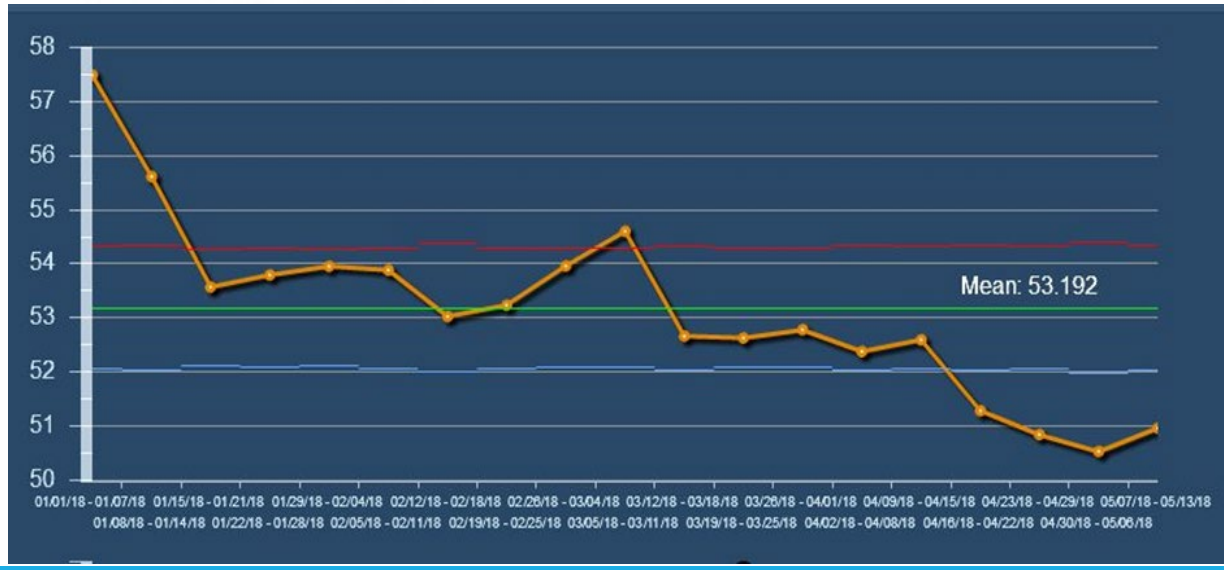


Case Example: Head CT Dose

4. Medical physicists visit site and implement ~10% dose reduction
5. Send out follow-up survey
6. If image quality ok, then repeat steps #4 & #5 until scanner at target dose



Counts/frequency: Equivalent image quality compared with prior head CT (7, 87.5%), Slight inferior quality, no significant difference in accuracy (0, 0.0%), Mild inferior quality, noticeable difference (1, 12.5%), Moderate inferior quality, significant difference (0, 0.0%), Severe inferior quality, non-diagnostic (0, 0.0%), (0, 0.0%), Superior image quality compared with prior head CT (0, 0.0%)



Solution: Creating Actionable Reports

Governance Group

- Generated monthly
- Includes data from all scanners
- Helps to identify system trends

Banner Health

1/2/2020

COMPUTED TOMOGRAPHY DOSE REDUCTION MONTHLY REPORT

CT Scanners using Iterative Reconstruction image processing

The purpose of this report is to provide an overview of the monthly Computed Tomography (CT) radiation dose delivered to patients throughout Banner Health. Each healthcare facitlity is provided a specific dose report that highlights opportunities for the each Medical Center Radiation Dose Reduction Committee to reduce patient dose. As the Dose Reduction Committees meet periodically to review imaging protocols and radiation dose, the reports compare the previous month's Computed Tomography Dose Index (CTDIvol) and Dose-Length Product (DLP) values to similar CT scanner models within Banner Health, other CT scanners within Banner Health, and National Benchmarks such as the American College of Radiology (ACR) Dose Index Registry (DIR).

This report provides data for the following:

Benchmark comparison of CT dose by CT machine model and manufacturer
Graphic comparison of CT dose by CT machine
Examples of dose optimization on selected CT machines
List of opportunities provided to each health care facility
List of CT protocol names used to generate data for this report

This report also is useful to demonstrate compliance with The Joint Commission requirements:

PC.01.02.15 EP5 Document the CT radiation dose index in a retrievable format
PC.01.02.15 EP10 Verify correct patient CT protocol and CT scan parameters
PC.01.03.01 EP25 Establish CT protocols including indication, contrast, age, size, and expected dose index range.
PC.01.03.01 EP26 Review CT protocols with input from a radiologist, medical physicist, and technologist.

CT Scanners using Iterative Reconstruction image processing and Filtered Backprojection image processing are separated for comparison to more adequately compare similar CT machines. This report is for CT Scanners using Iterative Reconstruction, which are usually newer machines that deliver less radiation dose.

The Banner Health CT dose reduction efforts are overseen by the Medical Imaging Clinical Consensus Group and follow the guidance established in the Banner Health Policy #3729 "*Patient Radiation Dose Reduction in Medical Imaging*"

[redacted]

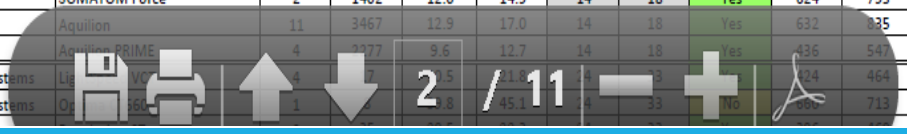
Paul Hanny, Ph.D., DABR
Corporate Radiation Safety Officer

Solution: Creating Actionable Reports

COMPUTED TOMOGRAPHY (Iterative Reconstruction) ADULT CT DOSE for the previous month

Medical Center CTs are grouped according to model and compared to all Banner Health CTs using Iterative Reconstruction techniques for image formation. The benchmarks are from the American College of Radiology Dose Index Registry (ACR DIR) and are compared at the 75th percentile. CTs exceeding the benchmark 75th percentile are good candidates for dose reduction. CTs with very low CTDIvol or DLPs are candidates to review for poor image quality.

Adult	December, 2019		Number of CTs	Number of exams	CTDIvol (mGy)					DLP (mGy·cm)				
							Benchmark		Is CTDI less than Benchmark?			Benchmark		Is DLP less than Benchmark?
					mean	75th	mean	75th		mean	75th	mean	75th	
Head	GE Medical Systems	LightSpeed VCT	4	402	52.0	53.7	54	61	Yes	878	967	857	1010	Yes
	GE Medical Systems	Optima CT660	1	83	37.8	39.8	54	61	Yes	625	648	857	1010	Yes
	GE Medical Systems	Revolution CT	2	669	43.0	45.7	54	61	Yes	725	877	857	1010	Yes
	GE Medical Systems	Revolution EVO	5	379	45.4	45.1	54	61	Yes	743	735	857	1010	Yes
	Philips	Brilliance 64	1	67	48.2	48.3	54	61	Yes	1077	1100	857	1010	No
	Philips	Ingenuity CT	1	587	48.4	48.4	54	61	Yes	1078	1131	857	1010	No
	Siemens	Biograph20	1	13	55.4	59.2	54	61	Yes	1038	1173	857	1010	No
	Siemens	SOMATOM Definition AS	5	100	39.2	52.8	54	61	Yes	672	865	857	1010	Yes
	Siemens	SOMATOM Definition AS+	3	688	52.9	59.0	54	61	Yes	990	1106	857	1010	Yes
	Siemens	SOMATOM Definition Flash	2	149	58.9	59.5	54	61	Yes	1114	1180	857	1010	No
	Siemens	SOMATOM Force	2	1330	54.9	58.2	54	61	Yes	1040	1113	857	1010	No
	Toshiba	Aquilion	11	2561	52.8	58.7	54	61	Yes	986	1079	857	1010	Yes
	Toshiba	Aquilion PRIME	4	859	54.6	57.5	54	61	Yes	974	1044	857	1010	Yes
Chest	GE Medical Systems	LightSpeed VCT	4	300	10.6	14.2	10	15	Yes	361	505	660	1029	Yes
	GE Medical Systems	Optima CT660	1	35	11.5	15.6	10	15	Yes	307	510	660	1029	Yes
	GE Medical Systems	Revolution CT	2	424	10.6	15.0	10	15	Yes	403	569	660	1029	Yes
	GE Medical Systems	Revolution EVO	5	205	9.4	13.1	10	15	Yes	326	459	660	1029	Yes
	Philips	Brilliance 64	1	32	9.9	12.1	10	15	Yes	386	478	660	1029	Yes
	Philips	Ingenuity CT	1	282	9.7	11.9	10	15	Yes	373	451	660	1029	Yes
	Siemens	Biograph20	1	39	7.2	8.0	10	15	Yes	216	245	660	1029	Yes
	Siemens	SOMATOM Definition AS	5	69	10.2	11.6	10	15	Yes	361	427	660	1029	Yes
	Siemens	SOMATOM Definition AS+	3	382	10.0	12.2	10	15	Yes	348	424	660	1029	Yes
	Siemens	SOMATOM Definition Flash	2	128	6.1	6.5	10	15	Yes	211	229	660	1029	Yes
	Siemens	SOMATOM Force	2	534	7.5	9.9	10	15	Yes	271	365	660	1029	Yes
	Toshiba	Aquilion	11	1486	10.6	13.9	10	15	Yes	384	515	660	1029	Yes
	Toshiba	Aquilion PRIME	4	444	8.9	10.8	10	15	Yes	343	416	660	1029	Yes
Abdomen	GE Medical Systems	LightSpeed VCT	4	532	11.5	15.9	14	18	Yes	580	809	476	633	Yes
	GE Medical Systems	Optima CT660	1	125	10.5	14.0	14	18	Yes	517	684	476	633	Yes
	GE Medical Systems	Revolution CT	2	736	8.0	9.4	14	18	Yes	427	518	476	633	Yes
	GE Medical Systems	Revolution EVO	5	419	8.9	11.0	14	18	Yes	430	542	476	633	Yes
	Philips	Brilliance 64	1	61	13.3	15.3	14	18	Yes	721	808	476	633	No
	Philips	Ingenuity CT	1	769	11.9	14.7	14	18	Yes	649	805	476	633	No
	Siemens	Biograph20	1	67	7.6	8.5	14	18	Yes	320	389	476	633	Yes
	Siemens	SOMATOM Definition AS	5	213	13.5	15.4	14	18	Yes	549	651	476	633	Yes
	Siemens	SOMATOM Definition AS+	3	1026	11.4	14.4	14	18	Yes	518	678	476	633	Yes
	Siemens	SOMATOM Definition Flash	2	366	11.9	15.5	14	18	Yes	506	696	476	633	Yes
	Siemens	SOMATOM Force	2	1402	12.0	14.9	14	18	Yes	624	793	476	633	Yes
	Toshiba	Aquilion	11	3467	12.9	17.0	14	18	Yes	632	835	476	633	Yes
	Toshiba	Aquilion PRIME	4	1277	9.6	12.7	14	18	Yes	436	547	476	633	Yes
Sinus	GE Medical Systems	LightSpeed VCT	4	385	12.5	21.6	14	33	Yes	524	464	408	649	Yes
	GE Medical Systems	Optima CT660	1	38	8.8	45.1	14	33	No	386	713	408	649	No



Solution: Creating Actionable Reports

Adult	December, 2019		Number of CTs	Number of exams	CTDIvol (mGy)				Is CTDI less than Benchmark?	DLP (mGy·cm)				Is DLP less than Benchmark?
							Benchmark					Benchmark		
					mean	75th	mean	75th		mean	75th	mean	75th	
Head	GE Medical Systems	LightSpeed VCT	4	402	52.0	53.7	54	61	Yes	878	967	857	1010	Yes
	GE Medical Systems	Optima CT660	1	83	37.8	39.8	54	61	Yes	625	648	857	1010	Yes
	GE Medical Systems	Revolution CT	2	669	43.0	45.7	54	61	Yes	725	877	857	1010	Yes
	GE Medical Systems	Revolution EVO	5	379	45.4	45.1	54	61	Yes	743	735	857	1010	Yes
	Philips	Brilliance 64	1	67	48.2	48.3	54	61	Yes	1077	1100	857	1010	No
	Philips	Ingenuity CT	1	587	48.4	48.4	54	61	Yes	1078	1131	857	1010	No
	Siemens	Biograph20	1	13	55.4	59.2	54	61	Yes	1038	1173	857	1010	No
	Siemens	SOMATOM Definition AS	5	100	39.2	52.8	54	61	Yes	672	865	857	1010	Yes
	Siemens	SOMATOM Definition AS+	3	688	52.9	59.0	54	61	Yes	990	1106	857	1010	Yes
	Siemens	SOMATOM Definition Flash	2	149	58.9	59.5	54	61	Yes	1114	1180	857	1010	No
	Siemens	SOMATOM Force	2	1330	54.9	58.2	54	61	Yes	1040	1113	857	1010	No
	Toshiba	Aquilion	11	2561	52.8	58.7	54	61	Yes	986	1079	857	1010	Yes
	Toshiba	Aquilion PRIME	4	859	54.6	57.5	54	61	Yes	974	1044	857	1010	Yes

Solution: Creating Actionable Reports

Governance Group

- Generated monthly
- Includes data from all scanners
- Helps to identify system trends

Opportunities for Optimization

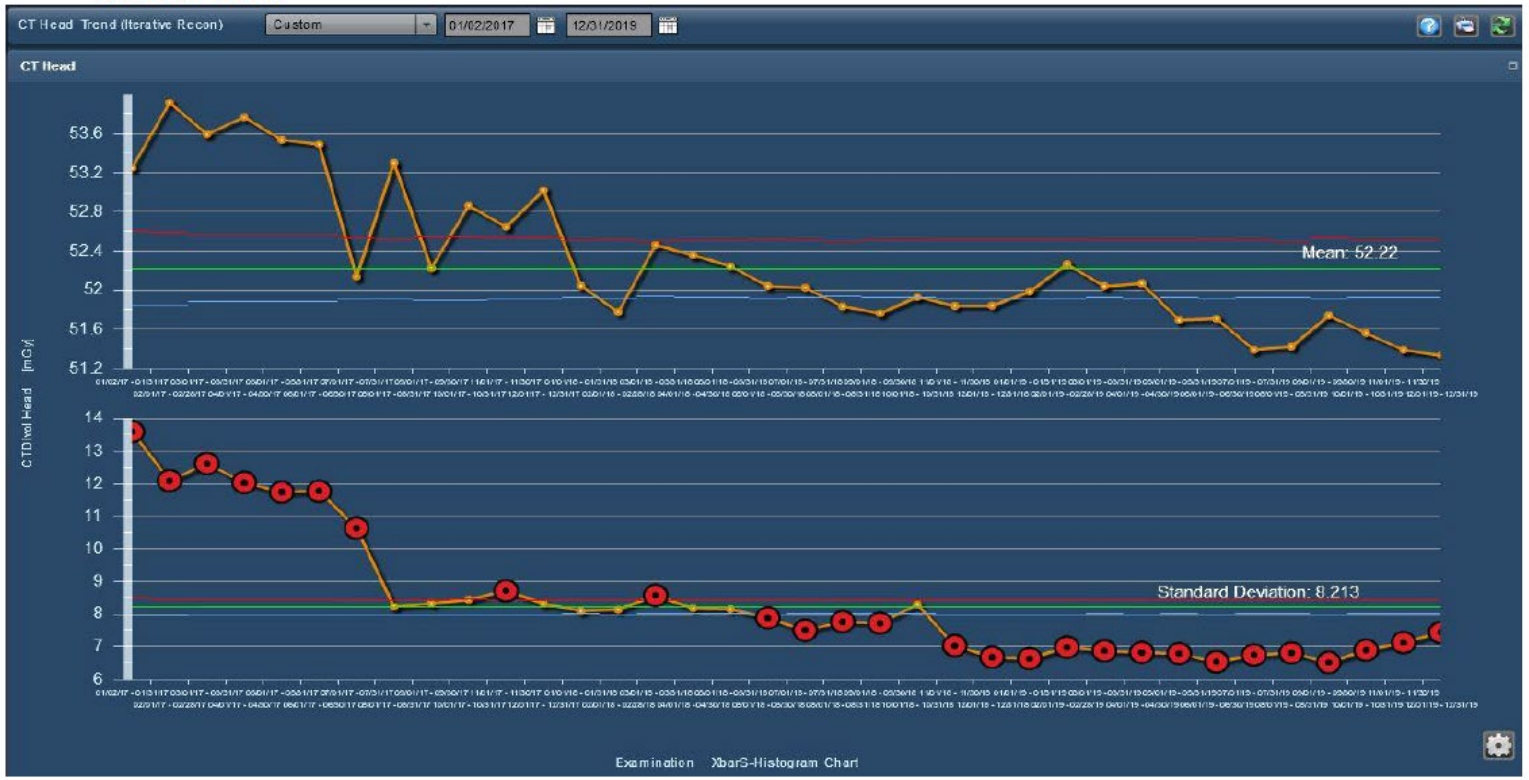
Banner health care facilities receive a detalied report once per quarter. This lis represents the 1/3 of the Banner Health facilties who received the January 2020 report using December 2019 data. The remaining facilties will receive their reorts in their selected month. The healthcare facitlities that have the listed CT machines below were provided a specific dose report that highlighted opportunities for the their Radiation Dose Reduction Committee to reduce patient dose.

CT	Protocol Set	Observation
BGMC_ED_CT Aquilion	Pediatric (3-6) CT Head	CTDIvol greater than benchmark
BGMC_ED_CT Aquilion	Pediatric (7-10) CT Head	CTDIvol greater than benchmark
BBMC_ED_CT Aquilion	Pediatric (7-10) CT Head	CTDIvol greater than benchmark

Trends and Results

Trends - Iterative Reconstruction CTs

Adult CT Head

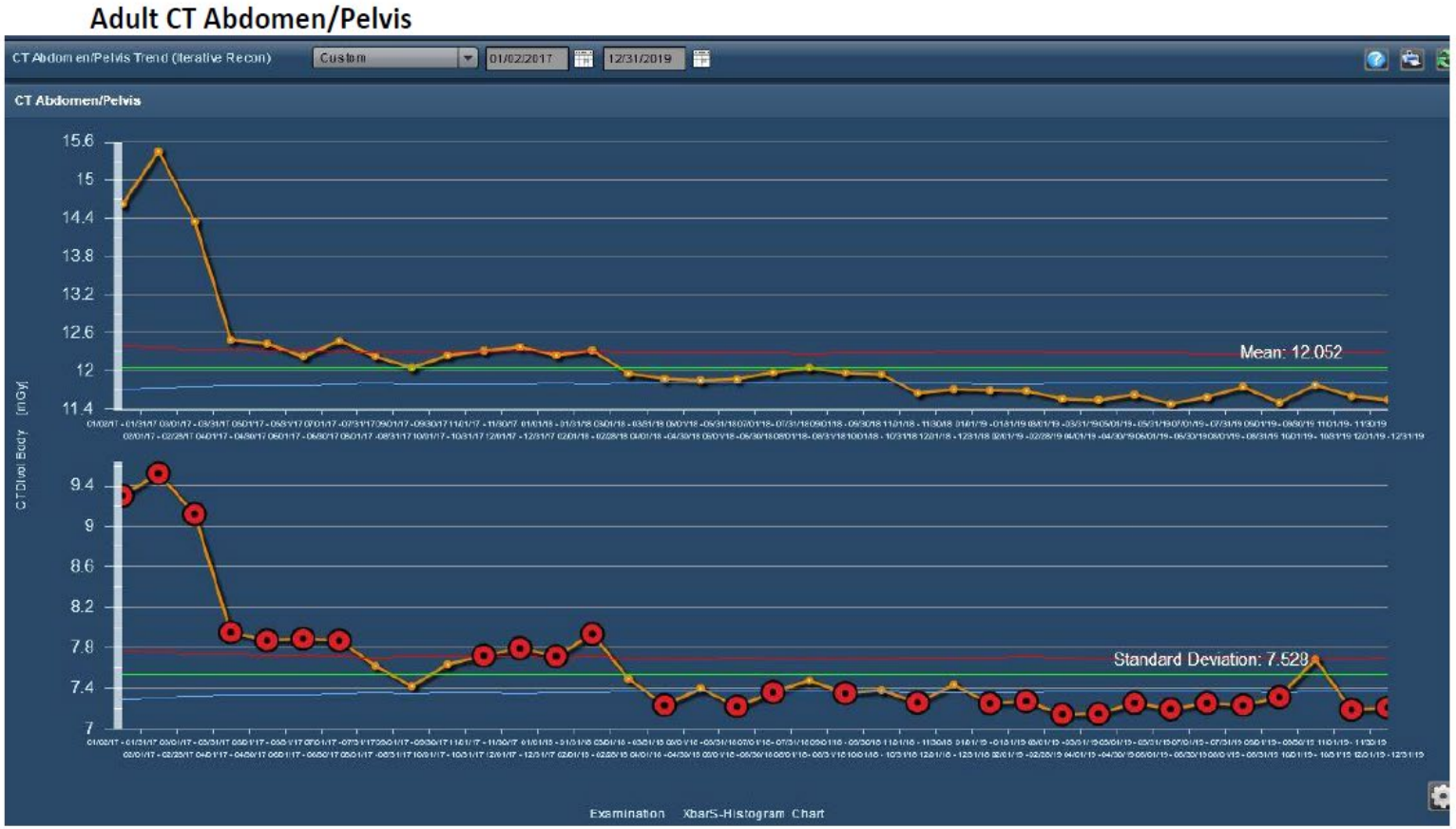


Trends and Results

Adult CT Chest

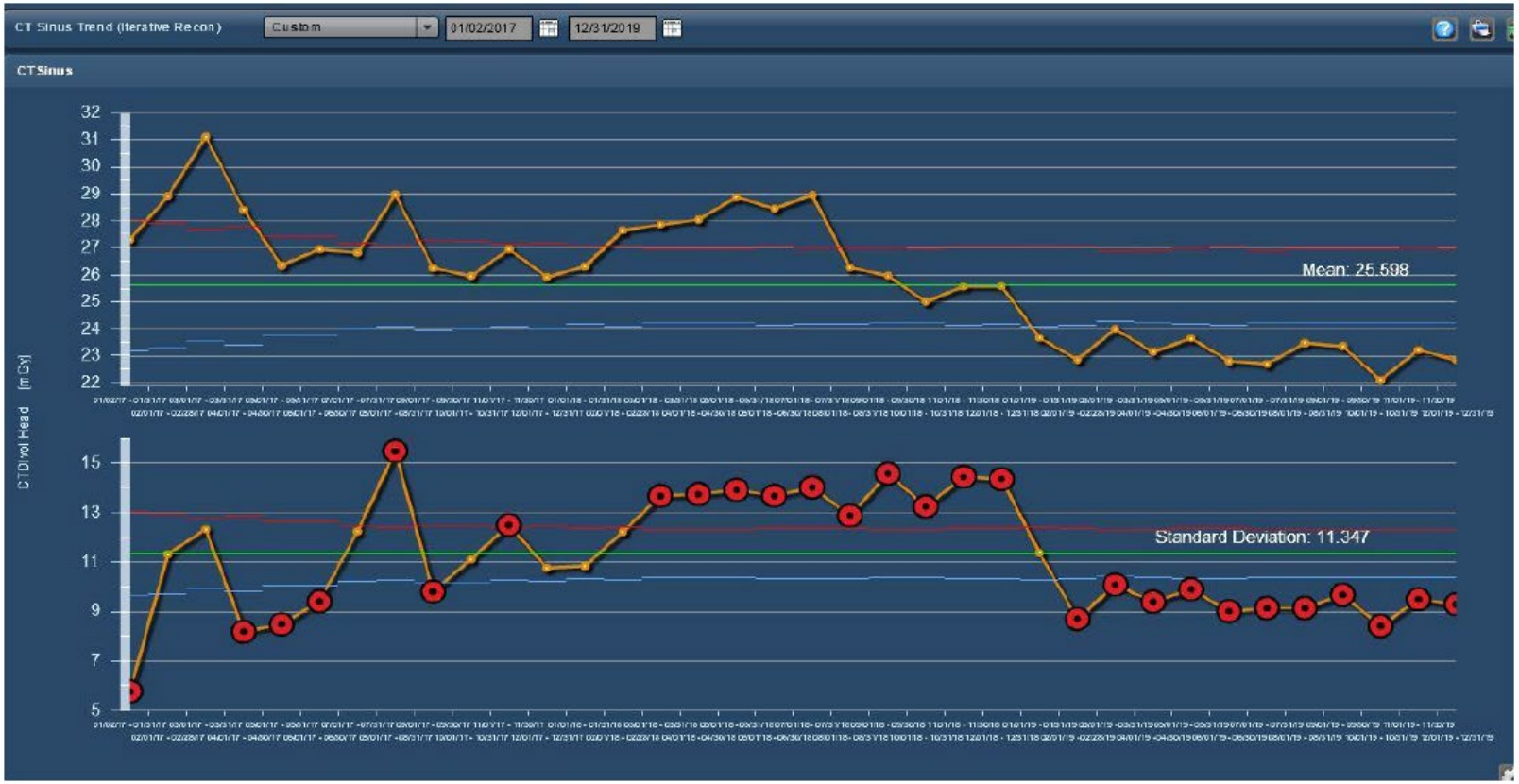


Trends and Results



Trends and Results

Adult CT Sinus



Trends and Results

Adult CT Neck



Lessons Learned

This takes a lot of work!

- Requires teamwork and resources

This takes a lot of time

Data needs to be accurate

- e.g. protocol mapping

Accountability

- Dashboard to track changes with color coded spreadsheet

Adult	April, 2018		Number of exams	CTDIvol (mGy)		Benchmark		Is CTDI less than Benchmark?	DLP (mGy·cm)		Benchmark		Is DLP less than Benchmark?
				mean	75th	mean	75th		mean	75th	mean	75th	
Head	BDWMC_ED_CT	SOMATOM Definition	809	45.9	48.8	54	61	Yes	850	922	857	1010	Yes
						54	61	-			857	1010	-
	Banner SOMATOM		957	46.5	50.0	54	61	Yes	860	930	857	1010	Yes
	Banner CTs (Iterative Recon)		5553	50.8	56.4	54	61	Yes	954	1070.8	857	1010	Yes
Chest	BDWMC_ED_CT	SOMATOM Definition	118	14.6	19.4	10	15	Yes	488	622	660	1029	Yes
						10	15	-			660	1029	-
	Banner SOMATOM		145	13.1	17.4	10	15	Yes	390	589	660	1029	Yes
	Banner CTs (Iterative Recon)		1408	9.9	12.6	10	15	Yes	326	433	660	1029	Yes
Abdomen	BDWMC_ED_CT	SOMATOM Definition	1358	13.2	15.7	14	18	Yes	646	787	476	633	No
						14	18	-			476	633	-
	Banner SOMATOM		1587	11.4	15.4	14	18	Yes	553	760	476	633	Yes
	Banner CTs (Iterative Recon)		8389	11.4	14.4	14	18	Yes	559	728	476	633	Yes
Sinus	BDWMC_ED_CT	SOMATOM Definition	19	32.8	40.6	24	33	Yes	657	814	408	649	No
						24	33	-			408	649	-
	Banner SOMATOM		28	24.3	34.0	24	33	Yes	485	724	408	649	Yes
	Banner CTs (Iterative Recon)		442	27.9	29.3175	24	33	Yes	591	670	408	649	Yes
Neck	BDWMC_ED_CT	SOMATOM Definition	26	7.9	8.7	15	20	Yes	235	273	422	589	Yes
						15	20	-			422	589	-
	Banner SOMATOM		37	7.8	8.7	15	20	Yes	221	274	422	589	Yes
	Banner CTs (Iterative Recon)		264	10.5	12.3	15	20	Yes	301	393	422	589	Yes

Work in Progress and Future Opportunities

What benchmarks to use?

- National
- Internal

Use different type of dose data?

- SSDE (size specific dose estimate) for pediatric patient population

Roll out system wide projects for other CT protocols

Eventually other modalities e.g. fluoroscopy

Special Thanks To Our Team!

Michael Morris, MD

Paul Hanny, Ph.D., RSO

Tim O'Dell (Radiology Director)

Raul Galvez MD

Administrative Support:

- James Steinshouer

Medical Physics

- Chris Waite-Jones (CO)

Technology Management/ ENTECH

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