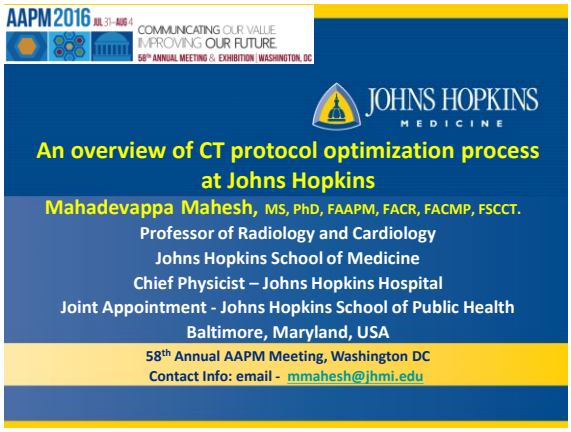

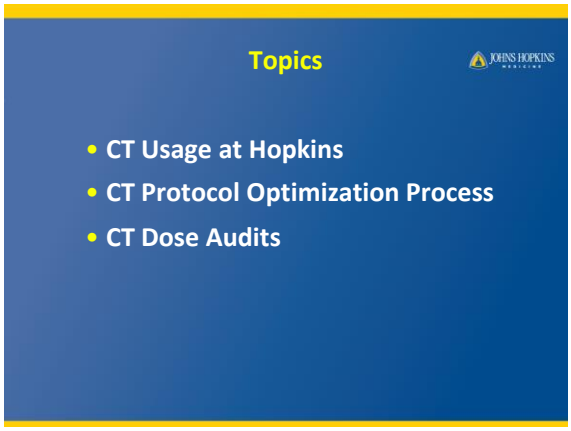

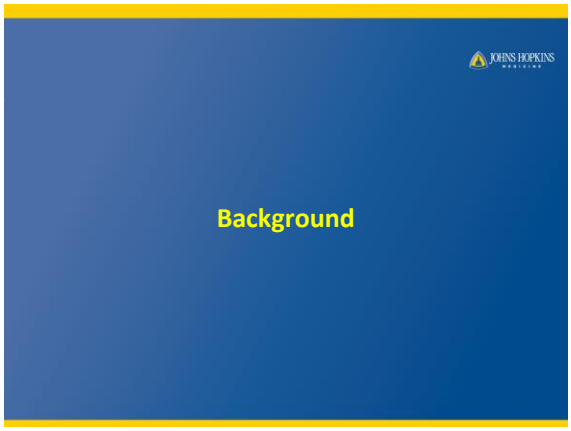

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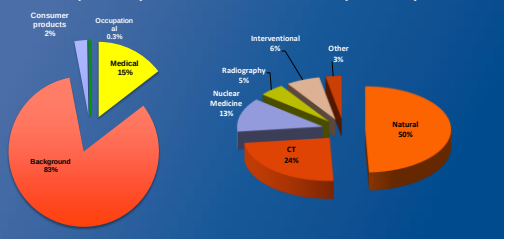
Radiation exposure to US population



Medical 0.54 mSv per capita
Total 3.6 mSv per capita

Medical 3.0 mSv per capita
Total 6.2 mSv per capita

NCRP 160 published March 2009

Radiation Injuries in CT – Rare but Possible!


The New York Times — Health

After Stroke Scans, Patients Face Serious Health Risks

When Alain Reyes's hair suddenly fell out in a freakish hand circling his head, he was not the only one worried about his health. His co-workers at a shipping company avoided him, and his boss sent him home, fearing he had a contagious disease.

2010

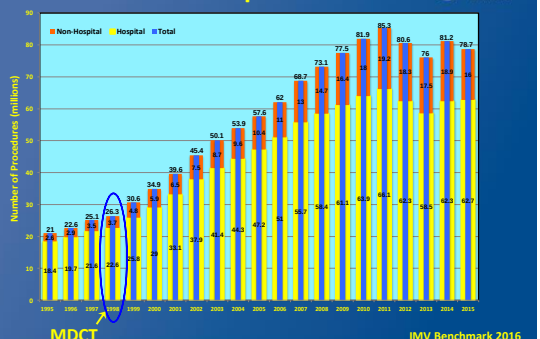
2011


West Virginia Hospital Overradiated Brain Scan Patients, Records Show

A large West Virginia hospital seriously overradiated patients suspected of having strokes with CT scans for more than a year after similar episodes prompted federal officials to alert hospitals nationwide to be especially careful when using these types of scans, interviews and documents show.

Radiation Boom, NY times

Number of CT procedures in US



IMV Benchmark 2016

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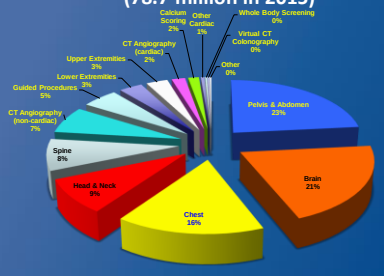
Categories of CT procedures

(78.7 million in 2015)



HCAP: ~76% of all CT procedures

IMV 2015

CT usage in US

CT Procedure Categories	Total 2015 CT Procedures (M)	% of All CT Procedures	% of CT Sites Performing
Head & Neck	23.2	30%	95%
Chest, Abdomen & Pelvis	37.3	47%	97%
Calcium Scoring	1.2	2%	30%
CT Angiography	1.5	2%	27%
Total 2015 CT Procedures	78.7	100%	

IMV 2015

CT Usage at Hopkins

- CT scanners in Radiology
  - Mostly single manufacturer scanners
  - 16 slice to 128 slice
- CT protocols are mostly uniform
- CT scanners in Cardiology
  - Single vendor
  - Facilitates optimization
- Hybrid Imaging systems
  - Limited number of CT protocols

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CT Safety Team

- Technologists (manager & QA tech)
- Physicist
- Radiologist (Body CT Director)

CT Physicist's Role

- Acceptance Tests
- Evaluation post major upgrade or repair
- CT Protocol Review with CT team
- CT Accreditation
- Quarterly Radiation Dose Audits
- Evaluation of high dose procedures such as CT Perfusion
- Evaluation of fetal dose for pregnant patients

CT protocol review

- 1st identify procedures that have high potential to cause injury and ensure the settings are ok
  - CT Perfusion – Brain or Cardiac, CT Fluoroscopy,…
- 2nd review protocols of most common CT studies
- 3rd review scan settings for all protocols
- Establish routine review of CT protocols
- Establish process to evaluate new CT protocols before setting up on scanner

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How request for protocol changes addressed?

- Request for protocol changes is reviewed by CT team
- CT Physicist review reason for such changes, its impact on CT dose
- Once approved CT Technologist (super user) is responsible for modifying changes
- Single point repository for any changes aid in avoiding surprises

CT Dose Check*

- "Radiation dose check feature will provide an alert to CT machine operators when recommendation radiation levels as determined by users are exceeded"
- $CTDI_{vol}$ and DLP values can be set for each scan series so that when values exceeds set levels, program will alert operator and if operator still wishes to continue with the changes then reasons are to be documented
- Program is capable of tracking changes for audit

* NEMA XR 25-2010

CT Dose Check and CT Dose Notification

- Regulatory requirements
  - Medicare reimbursements are reduced by 5% from January of 2016 and 15% a year after for CT scanner that are not in compliance regarding CT dose alert
- Refer to AAPM website* for notification values
  - User can modify according to their practice
- Check if scanner triggers by setting up test patient and modifying parameters to exceed alert values

http://www.aapm.org/pubs/CTProtocols/documents/NotificationLevelsStatement.pdf

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CT Dose Check

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CT Dose Alert

- US FDA has suggested CT alert value for $CTDI_{vol}$ of 1 Gy (1000 mGy)

CT Notification Values**

CT Scan Region (of each individual scan in an examination)	$CTDI_{vol}$ Notification Value (mGy)
Adult head	80
Adult torso	50
<2 years old	50
2-5 years old	60
Pediatric torso	
<10 years old(16-cm phantom)*	25
<10 years old (32-cm phantom)†	10
Brain Perfusion‡	600
Cardiac	
Retrospectively gated (spiral)	150
Prospectively gated (sequential)	50

**AAPM Dose Check Guidelines, 2011

* NEMA XR 25-2010

CT Dose Audits

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- Dose information recorded for every CT study
- In addition, CT Technologists randomly select up to five most commonly performed procedures on each scanner
- Record dose information of five patients for each identified procedure for review
- Also records all studies flagged under CT Dose Notification preset for respective protocols

CT Dose Audit

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- Physicist review select cases regarding radiation information and image quality
- Review studies flagged under CT dose notification especially review technologists notes for such studies

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Reviewing CT Protocols

CT Dose Audit – Initial Setup

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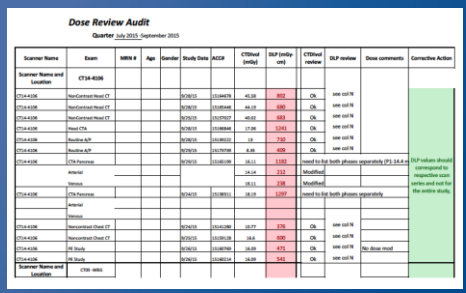

Dose Review Audit

Quarter July 2015 -September 2015

Scanner Name	Exam	MRN #	Age	Gender	Study Date	ACC#	CTDIvol (mGy)	DLP (mGy-cm)	CTDIvol review	DLP review	Dose comments	Corrective Action
Scanner Name and Location	CT14-4106											
CT14-4106	NonContrast Head CT				9/28/15	15104678	45.58	802	Ok	see cell N		
CT14-4106	NonContrast Head CT				9/28/15	15105448	46.18	690	Ok	see cell N		
CT14-4106	NonContrast Head CT				9/25/15	15107027	40.02	683	Ok	see cell N		
CT14-4106	Head CTA				9/28/15	15108048	17.08	1241	Ok	see cell N		
CT14-4106	Routine A/P				9/28/15	15108122	10	710	Ok	see cell N		
CT14-4106	Routine A/P				9/28/15	15107598	8.26	409	Ok	see cell N		
CT14-4106	CTA Pancreas				9/28/15	15108109	16.11	1152	need to list both phases separately (P) 14.4 m			DLP values should correspond to respective scan series and not for the entire study.
	Arterial						14.14	212	Modified			
	Venous						16.11	238	Modified			
CT14-4106	CTA Pancreas				9/24/15	15108911	16.19	1297	need to list both phases separately			
	Arterial											
	Venous											
CT14-4106	Noncontrast Chest CT				9/24/15	15141288	10.77	376	Ok	see cell N		
CT14-4106	Noncontrast Chest CT				9/25/15	15105128	16.6	600	Ok	see cell N		
CT14-4106	PE Study				9/26/15	15148708	16.09	471	Ok	see cell N	No dose mod	
CT14-4106	PE Study				9/26/15	15148214	16.09	541	Ok	see cell N		
Scanner Name and Location	CT09- WBG											

CT Dose Audit Data

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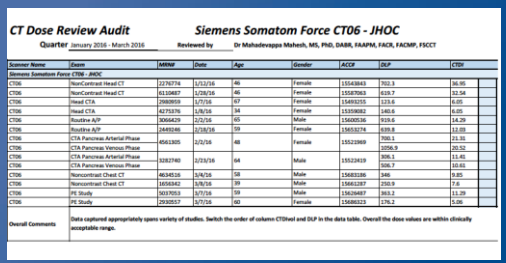

CT Dose Review Audit — **Siemens Somatom Force CT06 - JHOC**

Quarter January 2016 - March 2016 — Reviewed by Dr Mahadevappa Mahesh, MS, PhD, DABR, FAAPM, FACR, FACMP, FSCCT

Scanner Name	Exam	MRN#	Date	Age	Gender	ACC#	DLP	CTDI
Siemens Somatom Force CT06 - JHOC								
CT06	NonContrast Head CT	2276774	1/12/16	46	Female	15543843	702.3	56.95
CT06	NonContrast Head CT	6110487	1/28/16	46	Female	15587063	619.7	52.54
CT06	Head CTA	2860859	1/7/16	67	Female	15481015	123.6	6.05
CT06	Head CTA	4275376	1/8/16	34	Female	15359082	140.6	6.05
CT06	Routine A/P	3066429	2/3/16	65	Male	15600536	919.6	14.29
CT06	Routine A/P	1449246	1/18/16	59	Female	15651074	638.8	12.09
CT06	CTA Pancreas Arterial Phase	4561305	2/2/16	48	Female	15523969	700.1	21.31
CT06	CTA Pancreas Venous Phase						1056.9	20.52
CT06	CTA Pancreas Arterial Phase	3282740	2/23/16	64	Male	15523419	806.1	11.41
CT06	CTA Pancreas Venous Phase						1086.7	10.61
CT06	Noncontrast Chest CT	4634526	3/4/16	58	Male	15683186	346	9.85
CT06	Noncontrast Chest CT	1656542	3/8/16	39	Male	15681287	250.9	7.6
CT06	PE Study	5037053	3/7/16	59	Male	15626487	363.2	11.29
CT06	PE Study	2930557	3/7/16	60	Female	15686323	176.2	5.06
Overall Comments	Data captured appropriately spans variety of studies. Switch the order of column CTDIvol and DLP in the data table. Overall the dose values are within clinically acceptable range.							

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CT Dose Audits
Review of Dose Notification ALeerts

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Dose Notification/ Dose Alert Log

Date (dd-mm-yyyy)	Time (hh:mm:ss)	Patient ID		Type	Range	User name	Diagnostic reason	Password	CTDI (mGy)	CTDI limit (m	DLP (mGy*cm)	DLP
19-02-2016	9:23:07		1.2.840.113696	Dose notification	Venous		OBESE PATIENT		50.97	50	2598.7	
19-02-2016	4:36:01		1.2.840.113696	Dose notification	Monitoring		OBESE PT 320 LBS		92.46	80	92.5	
20-02-2016	2:46:17		1.2.840.113696	Dose notification	Head Routine		BODY HABITUS EXCEEDING		80.61	80	1465.3	
20-02-2016	2:48:38		1.2.840.113696	Dose notification	Monitoring		BODY HABITUS		525.1	100	525.1	
20-02-2016	18:58:30		1.2.840.113696	Dose notification	Monitoring		PATIENT BODY HABITUS		129.45	80	129.4	
23-02-2016	16:07:07		1.2.840.113696	Dose notification	Monitoring		525LB PT		92.46	80	92.5	
23-02-2016	16:07:07		1.2.840.113696	Dose notification	PE-Thorax		525LB PT		50.39	50	1674.4	
25-02-2016	12:40:32		1.2.840.113696	Dose notification	Head Routine		patient body habitus		81.16	80	1292.7	
26-02-2016	12:06:18		1.2.840.113696	Dose notification	Monitoring		patient body habitus		92.46	80	92.5	
26-02-2016	12:06:31		1.2.840.113696	Dose notification	Monitoring		patient body habitus		92.46	80	92.5	
26-02-2016	15:19:40		1.2.840.113696	Dose notification	Monitoring		OBESE PATIENT		147.94	80	147.9	
26-02-2016	15:19:40		1.2.840.113696	Dose notification	Arterial		OBESE PATIENT		61.1	50	2218.3	
26-02-2016	15:21:23		1.2.840.113696	Dose notification	Delay		OBESE PATIENT		60.32	50	2571.4	
27-02-2016	14:24:56		1.2.840.113696	Dose notification	Monitoring		patient body habitus and the first IV was not sufficient for study		92.46	80	92.5	
28-02-2016	19:21:15		1.2.840.113696	Dose notification	Monitoring		CTA		148.1	80	148.1	
4/5/16	16:29:46		1.2.840.113696	Dose notification	Routine AP		patient body habitus(407 weight)		53.93	50	2741.5	
5/5/16	20:07:32		1.2.840.113696	Dose notification	Monitoring		BODY HABITUS AND ARMS ARE DOWN		92.76	80	92.8	
7/5/16	1:17:01		1.2.840.113696	Dose notification	Routine AP		PT EXCEEDS 480LBS		70.34	50	3747.9	
7/5/16	1:17:58		1.2.840.113696	Dose notification	Routine AP		PT EXCEEDS 480LBS		70.34	50	3747.9	
7/5/16	1:18:54		1.2.840.113696	Dose notification	Routine AP		PT EXCEEDS 480LBS		54.72	50	2871.4	
8/5/16	15:47:16		1.2.840.113696	Dose notification	Monitoring		large pt		121.74	80	121.7	
9/5/16	16:54:37		1.2.840.113696	Dose notification	Chest Routine		patient body habitus 509lbs		69.49	50	3002.2	
9/5/16	19:28:20		1.2.840.113696	Dose notification	Monitoring		TOO BIG		92.46	80	92.5	
9/5/16	23:06:58		1.2.840.113696	Dose notification	Trauma CHEST		PT VERY OBESE AND UNABLE TO RAISE LEFT ARM		70.77	50	2737.1	
11/5/16	17:58:15		1.2.840.113696	Dose notification	Trauma Neuro		BODY HABITUS TOO BIG		82.67	80	3010.6	
11/5/16	19:50:23		1.2.840.113696	Dose notification	Monitoring		OBESE PT		111.06	80	111.1	

Overall Comments	This demonstrate that CT Dose Notification set on the scanner is working efficiently. My recommendation is to modify the notification value for monitoring protocols to 300 mGy instead of currently set values. Upon reviewing the cases, even though the system alerted dose notification, the actual CTDIvol for the monitoring protocols were well below the threshold set. Listed reasons are acceptable.

Quality Improvement Report

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DEPARTMENTAL QUALITY IMPROVEMENT QUARTERLY REPORT

Dept/Unit Radiology/CT

Date: December 28, 2015

Indicator: TJC PI 02.01.01.01 EP6

Indicator Numerator: 0

Indicator Denominator: 96 CT exams/quarter (Collect 12 CT studies per scanner--8 scanners. Include head, chest, abdomen and spine cases).

end of the year, the completed grid will contain all information needed for an annual evaluation of your department performance improvement.

	PLAN *What is the planned intervention/implementation for improvement?*	DO *What was done?*	STUDY *What did data analysis and assessment of effectiveness of intervention reveal?*	ACT *In response to data analysis, what is the action plan to either hold the gain achieved or to continue working toward improvement?*
Quarter 1, FY2016 (July, Aug, Sept 2015)	Collect data to evaluate dose acceptance on each CT scanner	Each quarter the JHH Physicist will review 96 cases for acceptable radiation dose.	Out of 96 cases 0% exceed the clinical expected dose range.	Will continue to collect data quarterly to monitor radiation dose in CT.
Quarter 2, FY2016 (Oct, Nov, Dec 2015)	Collect data to evaluate dose acceptance on each CT scanner	Each quarter the JHH Physicist will review 96 cases for acceptable radiation dose	Out of 96 cases 0% exceed the clinical expected dose range.	Will continue to collect data quarterly to monitor radiation dose in CT.

CT Technologists Role

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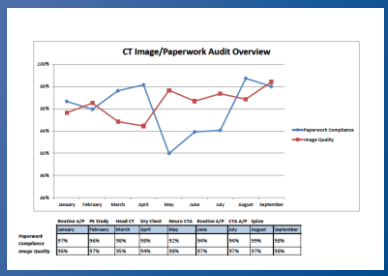
- Meets regularly (typically monthly)
- Purpose is to discuss difficult studies
- Peer review each others work on select studies
- Communicate regularly with physicist regarding questions related to patient scans

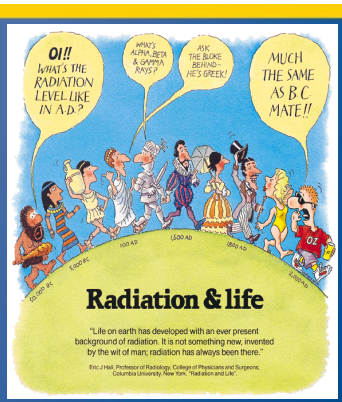
Technologists peer-peer review of CT scans



	Routine A/P	PE Study	Head CT	Dry Chest	Neuro CTA	Routine A/P	CTA A/P	Spine
	January	February	March	April	May	June	July	August	September
Paperwork Compliance	97%	96%	98%	98%	92%	94%	94%	99%	98%
Image Quality	96%	97%	95%	94%	98%	97%	97%	97%	98%

Conclusions

- CT protocol optimization is best achieved with team approach
- Periodic review of process is key to success
- Communication between all participants is key
- Irrespective of whether it is required by regulations or not, patient safety is our first priority – hence optimization is essential
- CT protocol optimization should ensure that image quality is not jeopardized



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