



Trends in the Radiation Used for Adult CT At the University of California San Francisco, 2010-2012

Pratik Mehta, B.A. ¹; Kate MacGregor, M.P.H. ²; Robert Gould, D.Sc. ²; Diana Miglioretti, Ph.D. ³; J. Anthony Seibert, Ph.D. ⁴; Rebecca Smith-Bindman, M.D. ²
David Geffen School of Medicine, University of California, Los Angeles ¹; Department of Radiology, University of California, San Francisco ²;
Department of Biostatistics, Group Health Research Institute, Seattle, WA ³; Department of Radiology, University of California, Davis ⁴



UCSF Radiology Outcomes Research Laboratory

Background:

Computed tomography (CT) imaging aids doctors in the diagnosis, management, treatment, and prevention of various diseases; however, concerns exist regarding the carcinogenic potential of the ionizing radiation emitted during the scans.

- Previous research has shown considerable variation (> 20-fold difference) in dose levels for patients presenting with the same symptoms within & across institutions.^{1,2}
- The ALARA principle holds that radiation doses should be “as low as reasonably achievable”

The University of California Dose Optimization and Standardization Endeavor (UC DOSE) is a collaboration of the five University of California Medical Centers (UMCs): UC San Francisco, UC Davis, UCLA, UC San Diego and UC Irvine, and is funded by the University of California Office of the President. The specific aims of the project are to:

- Assess and track radiation dose at each of the five institutions
- Optimize protocols to the lowest dose achievable, while maintaining diagnostic quality

The UMCs contribute and analyze dose data on all diagnostic CT protocols performed. By comparing doses across sites and evaluating the protocol machine settings (including kVp, mA, collimation, pitch, scan length, etc.), the UMCs will be able to determine the optimal settings for each protocol. The UC DOSE collaboration will establish a set of UC protocols with the goal to decrease the radiation exposure to patients without reducing the diagnostic efficacy of the exams.

Purpose:

As part of the UC DOSE project, the UMCs are independently assessing dose trends. This study highlights the value of comparing dose distribution datasets over time to understand changes in dose and the impact of any dose reduction strategies that may have been implemented. Specifically, we compare changes in dose from 2010 to 2012 at UCSF Medical Center. Using this data, we attempt to better understand which strategies have had the biggest impact on changing dose levels.

For this analysis, we compared dose levels within the four most commonly scanned anatomic regions (head, chest, abdomen/pelvis, and chest/abdomen/pelvis) from the eight scanners at three hospitals at UCSF.

UCSF will conduct a Virtual Symposium on Radiation Safety in CT May 8-10, 2013. Go to: rorl.radiology.ucsf.edu to learn more.

Methods:

Study Design:

The patient population for this study includes UCSF Medical Center patients (>17 years of age) undergoing a CT examination from February 1 to April 31 in both 2010 and 2012. For the purpose of our analysis, we looked at patients scanned within the Head, Chest, Abdomen/Pelvis, and Chest/Abdomen/Pelvis groups. Research and interventional CT studies were not included.

CT Equipment:

During our study period, we include data for five General Electric (GE) VCT machines, one GE Lightspeed Ultra 16-slice machine, one GE Lightspeed QX/ I 4-slice machine (used in 2010 only), a Neurologica Ceretom machine (limited to portable CNS exams on ICU patients). Four of the VCT machines installed ASIR software in 2011 allowing assessment on these machines of the impact of ASIR. The fifth VCT machine installed ASIR following the study period.

Dose Analytic Software:

We gathered dose information using eXposure™ (Radimetrics, Ontario, Canada) dose analytic software. The software extracts the CTDIvol and DLP from the Digital Imaging and Communications in Medicine (DICOM) headers in the PACS data, and combines these values with images and patient demographic information, to calculate size-specific dose estimates (SSDE), organ doses and effective doses, using ICRP 103 weighting factors for each patient.

CTDIvol can be most easily thought of as the average dose per slice. For the purpose of comparing CTDIvol estimates across exams that may have included several series, we used a calculated average of CTDI per slice for the exam.

UCSF Dose Reduction Strategies:

There have been increased efforts at UCSF Medical Center to reduce diagnostic CT radiation levels in recent years. Some of the strategies include:

- Increased technologist training
- Specified instructions to avoid over scanning
- Reduction of the kVp from 120 to 100 for patients under 100 lbs. in weight
- Reduction of the mA for chest and abdomen/pelvis exams by an average of 5% by adjusting the Noise Index used by automatic tube current modulation
- Reduction in use and elimination of certain higher dose and multiphase protocols
- Increased use of shielding where appropriate
- The installation of ASIR software

By linking institutional dose-reduction strategies with specific exams and machines, we explored reasons for the changes in dose over time.

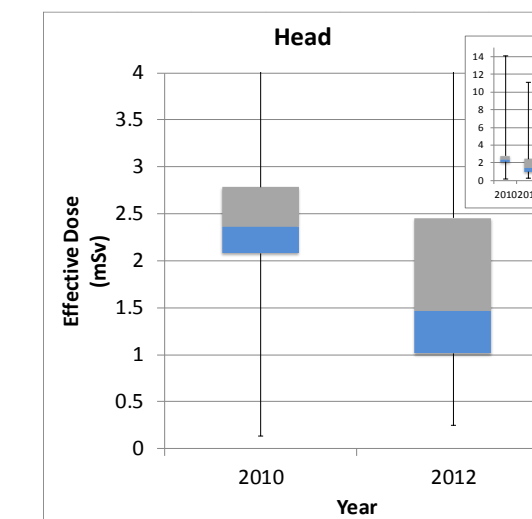
Results:

Radiation Dose Metrics:

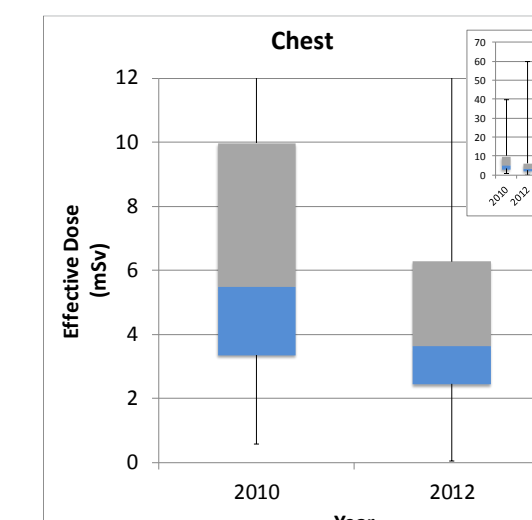
We observed four radiation exposure metrics: CTDI, DLP, SSDE, and effective dose (ICRP 103). We used the conversion factors outlined by AAPM Task Group #204 to estimate SSDE. Effective Dose is calculated using conversion factors outlined in the International Commission on Radiation Protection Publication 103.

Trends By Anatomic Region:

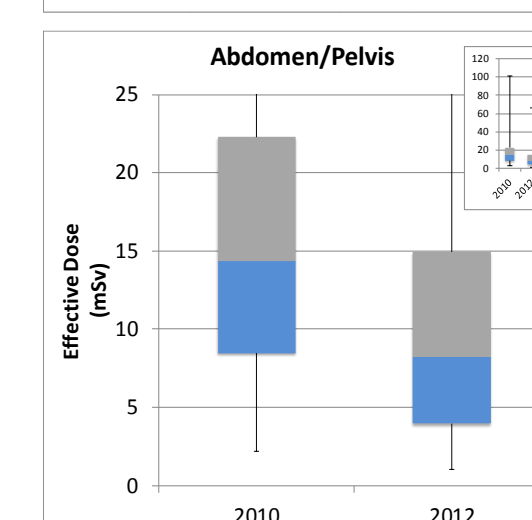
We collected data on 10,793 exams performed in total. Among adults, the average effective dose declined 22-36% within the observed anatomic regions from 2010 to 2012. The difference in the dose decline percentage between CTDI and SSDE was <3% in all anatomic regions. The difference in the dose decline percentage between CTDI and Effective Dose ranged from 3-20%, with 20% difference being the highest in CAP exams.



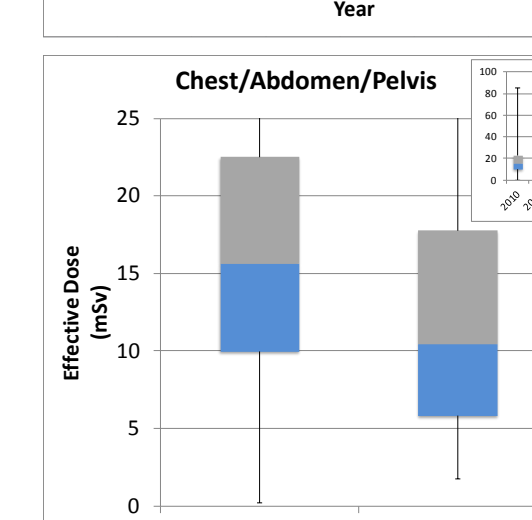
Head Exams	
Sample Size:	2010 N = 1352
	2012 N = 1402
Mean CTDIvol	declined 32% (56 to 38 mGy)
Mean SSDE	declined 35% (55 to 36 mGy)
Mean DLP	declined 35% (1408 to 917 mGy*cm)
Mean ED	declined 35% (2.8 mSv to 1.8 mSv)
Highest 10%	declined from 4.8 to 3.0 mSv



Chest Exams	
Sample Size:	2010 N = 1144
	2012 N = 1143
Mean CTDIvol	declined 44% (10 to 6 mGy)
Mean SSDE	declined 44% (13 to 7 mGy)
Mean DLP	declined 28% (367 to 263 mGy*cm)
Mean ED	declined 31% (7.2 mSv to 5.0 mSv)
Highest 10%	declined from 13.6 to 9.7 mSv



Abdomen/Pelvis Exams	
Sample Size:	2010 N = 2218
	2012 N = 1750
Mean CTDIvol	declined 42% (13 to 8 mGy)
Mean SSDE	declined 45% (16 to 9 mGy)
Mean DLP	declined 35% (1043 to 676 mGy*cm)
Mean ED	declined 36% (17.4 mSv to 11.1 mSv)
Highest 10%	declined from 35.0 to 22.7 mSv



Chest/Abdomen/Pelvis Exams	
Sample Size:	2010 N = 897
	2012 N = 887
Mean CTDIvol	declined 42% (13 to 8 mGy)
Mean SSDE	declined 45% (16 to 9 mGy)
Mean DLP	declined 21% (1016 to 805 mGy*cm)
Mean ED	declined 22% (17.7 mSv to 13.7 mSv)
Highest 10%	declined from 31.2 to 26.4 mSv

Results (continued):

UCSF performed 50 more head exams, 1 less chest exam, 468 less abdomen/pelvis exams, and 10 less chest/abdomen/pelvis exams from February 1 to April 30 in 2012 in comparison to 2010.

Trends by Machine and Settings Used:

Doses on machines that installed the adaptive statistical iterative reconstruction (ASIR) software in 2012 declined 38-49% for head protocols, 30-45% for chest protocols, and 36-55% for abdomen/pelvis protocols. Doses declined 7% for abdomen/pelvis protocols, 32% for head protocols, and 9% for chest protocols on machines that did not have ASIR installed in 2012. For the chest/abdomen/pelvis exams, doses on machines installing ASIR in 2012 decreased 54% on one machine and increased 5% on another. For CAP exams on machines without ASIR, doses declined 12% on one and increased 8% on another.

Discussion:

UCSF efforts to reduce dose from 2010 to 2012 have been effective with significant reductions in the four anatomic regions observed. Although it is not highlighted in our data, this in part reflects the reduction in the use of higher dose protocols, reduction in the use of multiphase protocols and a reduction in the average mA used on the scanners. Machines with ASIR installed in 2011 had greater dose reductions in comparison with machines that did not install the software. Therefore, ASIR has been a major contributor to the reduction of dose observed at UCSF. We did not assess diagnostic quality as part of this study, however this is assessed at weekly meetings across all of the specialty areas and at the radiation safety meeting and impacts the choice of settings to maintain quality

With increased attention given to CT dose radiation, facilities should make efforts to evaluate their dose levels and make efforts to implement the ALARA principle. Simple comparisons over time in the distribution of dose can be informative and should be routinely performed.

Senate Bill 1237:

- In California, Senator Alex Padilla authored Senate Bill 1237 requiring facilities to record CT radiation doses in patient medical records
- Facilities must also have a medical physicist review the dose for each exam
- An amendment to the bill (in effect July 1, 2013) requires facilities to report any dose exposures exceeding specified levels to the physician, patient and the California Department of Public Health

Although the reporting requirements of Senate Bill 1237 will identify exceedingly high radiation overexposures, it does not allow California facilities to compare their performance to other institutions. To address this concern, the UCSF CT Radiation Dose Patient Safety Measure (NQF #0739) endorsed by the National Quality Forum, allows any facility that wants to assess their performance to upload CT dose data to compare doses to benchmarks and to receive a report comparing their facility dose distribution (within each anatomic region) with national and regional levels. (rorl.radiology.ucsf.edu)

References:

¹Smith-Bindman R, Lipson J, Marcus R, et al. Radiation dose associated with common computed tomography examinations and the associated lifetime attributable risk of cancer. *Arch Intern Med.* Dec 14 2009;169(22):2078-2086.

²Smith-Bindman R, Miglioretti DL, Johnson E, et al. Use of diagnostic imaging studies and associated radiation exposure for patients enrolled in large integrated health care systems, 1996-2010. *Jama.* Jun 13 2012;307(22):2400-2409.



University of California
San Francisco