The Effect of Technical Parameters in Practice on Abdominal Computed Tomography (CT) Dose

Yifei Wang, PhD[1], Philip W. Chu[1], Sophronia Yu, MPH[1], Diana Miglioretti, PhD[2], Rebecca Smith-Bindman, MD[1]

[1]*University of California, San Francisco* [2]*University of California, Davis*

SUMMARY

- Radiation doses for CT are highly variable both within and across institutions.
- As part of a PCORI and NIH funded study, we created a CT radiation dose registry, using Bayer Radimetrics software, from 151 institutions across seven countries.
- Lowering patients' exposure to radiation, a known carcinogen, requires understanding factors contributing to this variation.
- Understanding reasons for variation in CT doses can guide future optimization strategies

BACKGROUND

- Approximately 80 million CT scans are performed annually in the US, averaging one per four individuals per year.
- Despite the large number of CT scans that are performed, there are few standards for the conduct of these studies.
- We have found radiation dose from CT exams can vary dramatically both within and across institutions suggesting opportunities in quality improvement.
- Much of the variation comes from differences in the use of technical parameters when conducting each scan.

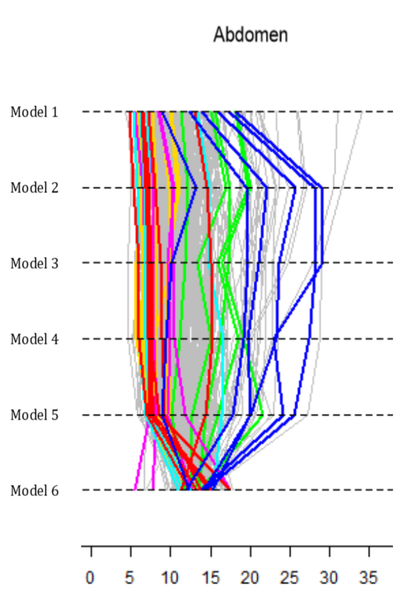
METHODS

- Using Bayer Radimetrics software, we created an aggregated CT radiation dose registry on a single server at UCSF, including 1.85 million adult (>=15 years) CT examinations conducted between January 1, 2017 and December 31, 2017.
- We excluded scans done for invasive procedures and research purposes.
- Radimetrics calculated the average effective dose (ED) in mSv by summing organ doses using ICRP103 weighting factors.
- We estimated the relative contributions of technical parameters to mean dose length product (DLP) and proportions of high-dose examinations for abdomen CT, after adjusting for patient & institutional characteristics, and scanner model, using hierarchical and logistic regression, respectively.

RESULTS

- A summary of our findings are presented in the accompanying tables and figures.
- Mean DLP and proportion of high-dose examinations varied modestly (10–50%) by institutional characteristics and scanner model after adjusting for patient characteristics (age, sex and size).
- In multivariable models, dose variation was primarily attributable to institutional differences in the use of technical parameters. When accounting for technical parameters, the differences between institutions were attenuated or eliminated.
- In our data, mAs accounted for the largest difference in dose between countries, and was twice as important as the other factors. For each standard deviation change in the log-transformed mAs, the average DLP increased by 60%.
- Variation in the use of multiphase scanning was the next most important factor explaining variation in DLP. With each standard deviation change in the log-transformed phase count, the average DLP increased by 51%.
- A typical change in mAs and phase count had twice the effect on dose as typical changes in other parameters.
- For every increase in log transformed standard deviation change in technical parameters, there was a 23% increase in DLP for scan length, a 21% decrease for pitch, an 18% increase for kvp, and a 4% decrease for slice thickness.
- In order of magnitude, the technical parameters most influential on abdominal dose were: mAs, phase count, scan length, pitch, kvp, and slice thickness.

Table 1: Mean Effective Dose by Scanner



Analytic Model	Mean Relative Dose	95% Relative Dose	Mean Effective Dose By Country (mSv) CH	NL	DE	UK	US	IL	JP
Unadjusted	1.39	2.65	7.3	7.6	7.3	7.5	11.4	15.7	14.4
(+) Patient Factors	1.40	2.65	8.8	8.3	8.1	8.2	12.3	17.3	22.9
(+) Scan Volumes and Time	1.39	2.58	8.6	8.8	8.6	7.9	11.9	15.0	22.0
(+) Manufacturer	1.38	2.49	8.8	8.8	8.6	7.6	11.8	16.0	20.3
(+) Machine Model	1.33	2.25	9.3	9.1	8.9	8.1	11.8	15.0	19.4
(+) Technical Factors	1.10	1.42	10.8	12.4	14.0	12.2	13.0	12.9	13.7

Table 2: Distribution of technical parameters between low and high dose scans

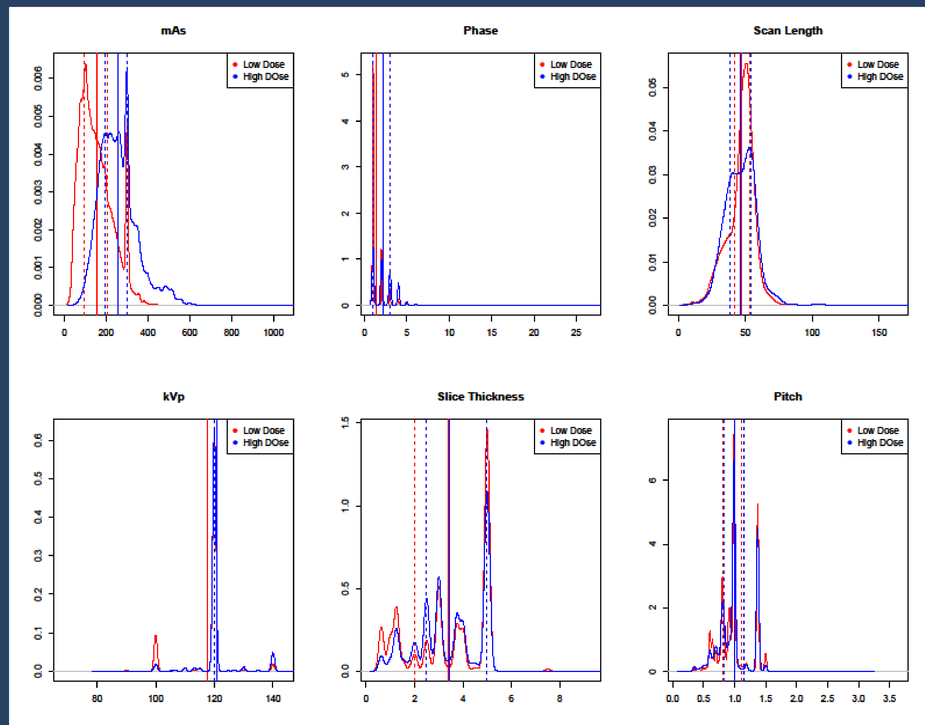
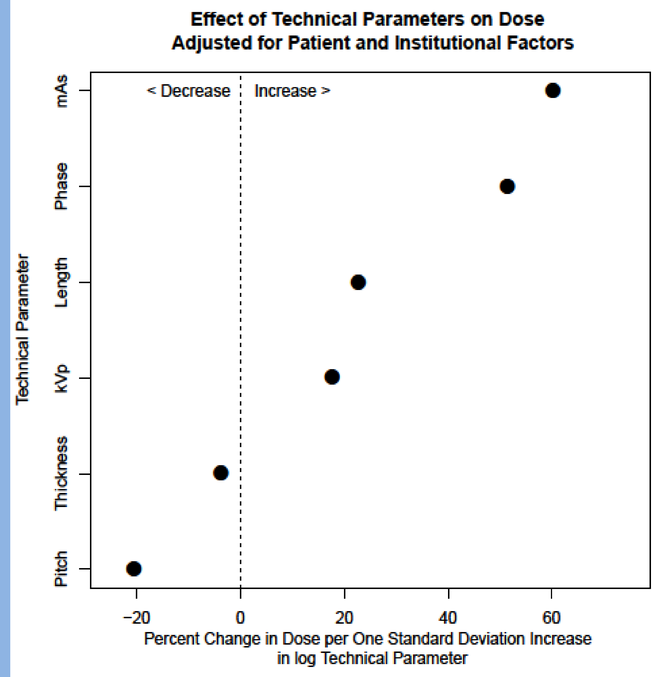


Table 3: Ranking the Effect of Technical Parameters on Dose



CONCLUSION

- Differences between abdomen doses across institutions were largely attenuated when controlling for dose technical parameters, to a degree not seen when controlling for patient, institutional characteristics, and scanner model
- These results demonstrate that CT scanner make and model play a relatively modest role, in comparison to technical parameters, as predictors of radiation dose.
- Optimum standardized protocols for computed tomography (CT) should be developed to ensure patient safety.

NEXT STEPS

- Expanding the CT Dose registry to include more countries, manufacturers, machine models, and other factors potentially affecting radiation dose.