Pushing Limits: Are We Scanning Too Far?

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Introduction

- Identifying ways to reduce medical imaging radiation dose is an important public health initiative.
- CT-related dose is the primary driver for increasing population medical radiation exposure.
- Epidemiological evidence of small increase in cancer risk attributable to ionizing radiation.
- ALARA mandates that any radiation dose, no matter how small, without direct benefit, should be avoided.
- ACR established a joint task force with the RSNA to create the *Image Wisely* campaign to increase awareness about adult radiation protection.
- Significant efforts to reduce radiation dose by adjusting parameters including: number of scan phases, tube voltage and current, scan pitch, and applying iterative reconstruction techniques
- Studies show that in almost every CT scan, the imaged volume is larger than the actual volume of interest, with an associated linear increase in radiation dose.
- Historically, oncologic chest CTs were extended inferiorly to include the adrenal glands. Additionally, many CT angiograms extend the field of view to include the abdominal aorta.
- Since there are no formally mandated anatomic landmarks on the scout tomogram, it is left to the technologists' discretion to determine the field of view. We believe that this has led to a *"creep"* phenomenon where many CTs extend far into the abdomen, providing extra radiation risk and uncertain benefit for the patient.
- To address this concern, we introduced new practice standards to ensure patient safety by setting exact anatomic limits to chest CTs.
- In this way, we can assure a comparable, safe radiation dose to every patient without site to site and technologist to technologist variability.

The purpose of this study was to implement a lasting intervention to decrease unnecessary radiation dose by reduction of Chest CT scan length.

Methods

- In September 2018, we created a task force to implement anatomic guidelines for CT chest exams.
- In collaboration with the chest division leadership, we trained radiologists, technical supervisors, and technologists to set the superior and inferior margins as the lung apices on the frontal scout view and the posterior costophrenic sulci on the lateral scout view, respectively.
- Technical supervisors provide daily support and assist technicians to enforce the anatomic guidelines. Continuous feedback from physicians using our Radiology Information System which provides a messaging mechanism to alert technical staff about scan deficiencies at the time of interpretation.
- **Primary outcome:** radiation dose of our most common chest CT applications - routine non-contrast chest and contrast enhanced pulmonary embolism protocol
- **Performance indicators:** CT dose index (CTDIvol) and dose-length product (DLP) which were mined from every exam using the DoseMonitor software for a 4 month period prior to and after our intervention. The month of the intervention was excluded.
- **Negative control:** ACR instituted guidelines in 2014 to include only the lung parenchyma on lung cancer screening examinations which were implemented in our institution.
- To assess the statistical significance of the dose reduction, we used linear regression models with the log-transformed CTDIvol and DLP as the response, pre and post time periods as the explanatory variable, and age, gender, and weight as covariates.

Results

- CTDIvol and DLP values for 3110 routine chest CTs prior to and 3109 routine chest CTs after our intervention, for 1629 PE studies prior to and 1831 PE studies after our intervention, and for 688 lung cancer screening studies prior to and 612 lung cancer screening studies after our intervention (Table 1).
- Statistically significant reduction in DLP in both routine non-contrast (4.76%, p=1.1e-5) and pulmonary embolism protocol (5.8%, p=3.4e-7) chest CTs (Table 1).
- As expected, there was no statistically significant reduction in CTDIvol or DLP in the lung cancer screening studies.
- Marginal reduction in CTDIvol in the routine chest CTs (1.93%, p=0.03).

Results

Table 1: Percent change of the pre and post CTDIvol and DLP values in routine, pulmonary embolism protocol, and lung cancer screening chest CTs.

*Adjusted for sex, weight, and age

	CTDI (mGy) DLP (mGy*cm)	Median	IQR	% Change*	P value
Routine Chest CT	Pre CTDI	4.79	3.19-6.91	-1.93%	0.033
	Post CTDI	4.62	3.10-6.84		
	Pre DLP	179.62	118.95-259.04	-4.76%	$3.39x10^{-7}$
	Post DLP	170.14	113.40-246.10		
Pulmonary Embolism Protocol	Pre CTDI	6.47	4.21-10.75	0.3%	0.90
	Post CTDI	6.68	4.17-10.96		
	Pre DLP	225.90	145.47-374.98	-5.8%	$1.13x10^{-5}$
	Post DLP	217.30	137.02-357.54		
Lung Cancer Screening	Pre CTDI	1.36	1.32-1.95	-1.57%	0.208
	Post CTDI	1.41	1.32-1.42		
	Pre DLP	53.20	49.37-82.81	-2.83%	0.076
	Post DLP	52.48	48.80-59.20		

Routine Chest CTs:

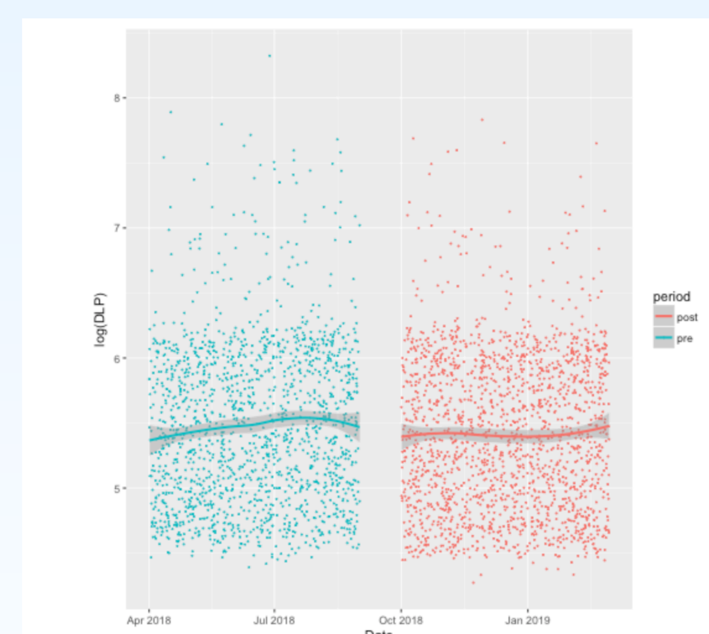

Figure 1

Pulmonary Embolism Chest CTs:

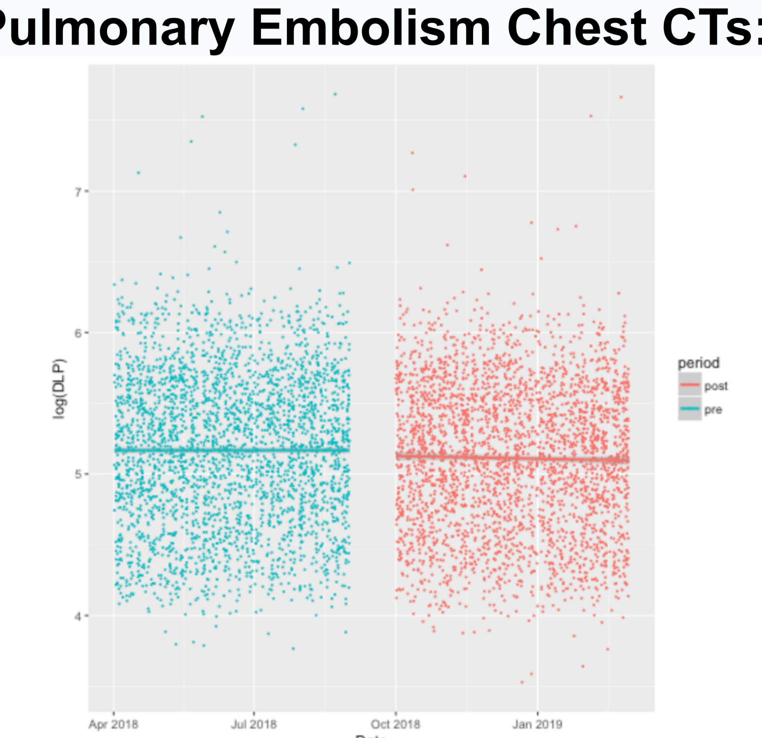

Figure 2

Figures 1 and 2: (1) Routine and (2) Pulmonary embolism protocol chest CT DLP values prior to and after the intervention (p<0.001)

Results

- Creation of smoothing lines showed no evidence of return to pre-intervention dose levels for several months post-intervention (Figures 1 and 2).
- Report analysis of 100 pre and 100 post noncontrast chest CTs showed no difference in the number of incidental abdominal findings (62/100 cases had one or more finding both before and after intervention).
  - Further imaging was recommended for 1/100 of the pre and 2/100 of the post CTs for evaluation of abdominal findings.
  - No report mentioned that portions of the lungs were cut off in the 100 pre or 100 post chest CTs analyzed.

Conclusions

- Using strict anatomic guidelines to scan from the lung apices to the posterior costophrenic sulci on the scout radiographs, we were able to slightly but significantly reduce radiation dose to the patient for routine and pulmonary embolism protocol chest CTs. The intervention appeared to have a lasting effect over several months.
- Further research may help assess the impact of better anatomic guidelines on incidental abdominal findings.
- Our aim is to further standardize scan lengths for other body regions in our institution and justify more exact global practice guidelines for routine CT imaging which are similar to those already instated for lung cancer screening CT studies.

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