A comprehensive CT radiation dose reduction and protocol standardization program in a complex tertiary hospital system

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Disclosures

- **Prabhakar Rajiah** - Institutional Research Grant, Koninklijke Philips NV Speaker, Koninklijke Philips NV
- **Travis Browning** - Advisor, McKesson Corporation
- **Avneesh Chhabra** - Consultant, ICON plc Author with royalties, Wolters Kluwer nv Author with royalties, Jaypee Brothers Medical Publishers Ltd
- **Sanjeeva Kalva** - Consultant, CeloNova Biosciences, Inc
- **Suhny Abbara** -Author, Reed Elsevier Editor, Reed Elsevier Institutional research agreement, Koninklijke Philips NV Institutional research agreement, Siemens AG

Background

- **Radiation doses from CT-** Leading cause of non-background radiation exposure
- Radiation dose should be maintained As Low As Reasonably Achievable
- Revised requirements of The Joint Commission
  - Radiation dose of every CT exam should be recorded
  - Investigation of cases where radiation dose exceeds reference levels
- Establishing a real-world radiation dose reduction program is challenging

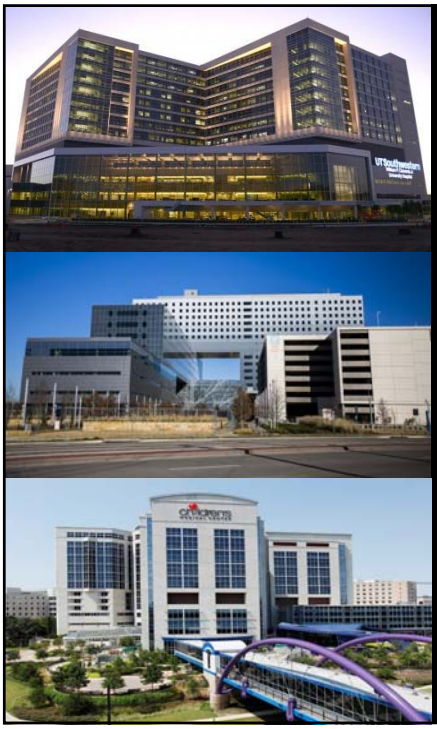
Purpose

- Establishing a CT radiation dose reduction program in a large complex health system is not widely reported
- We describe a comprehensive radiation dose reduction and protocol homogenization program in a large complex system using
  - Iterative process of lowest common denominator using phantom and clinical test cases
  - Novel web-based information distribution system

The problem

Review of the CT protocols and radiation doses identified the following problems

- Extensive heterogeneity of CT radiation doses
- Extensive heterogeneity of CT protocols
- No established parameters
- Lack of training and reliable dissemination
- No robust radiation dose tracking process
- Lack of uniform data storage



Challenges

3 health systems	4 large hospitals	5 outpatient centers
Several remote locations	3 PACS systems	4 major manufacturers
21 CT systems + 9 hybrid CT	Brand new to > 10-year-old equipment	6-slice hybrid CT to 320 slice scanners

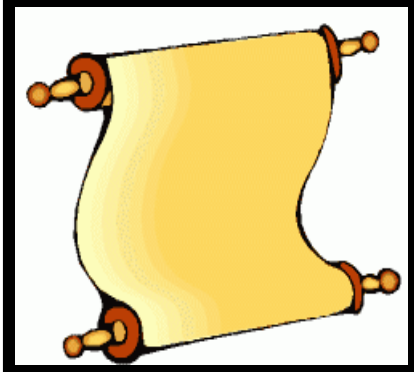
Problems

- Several, heterogeneous protocols
- Each location had local imaging protocols governed by local administrative body
- Different machines- multiple vendors; different software, hardware, weight limitations, etc
- Heterogeneous radiation doses for same protocols at different sites
- Variable maintenance of protocols at sites, paper or electronic
- Difficult to obtain protocols from another location without a phone call/email

CT Radiation Task Force

- A CT radiation task force was created
- Weekly CT operations meeting was established
- Coordination of stakeholders- Physicians, physicists, technologists and hospital administrators

CT Radiation Task Force- Aims



- To optimize patient radiation dose across scanners
- To standardize and homogenize the scan protocols and their names
- To maintain or improve image quality
- To establish mechanisms to continually track the dose
- To establish a reliable training and dissemination processes
- To make protocols readily available
- To ensure adherence to imaging protocols

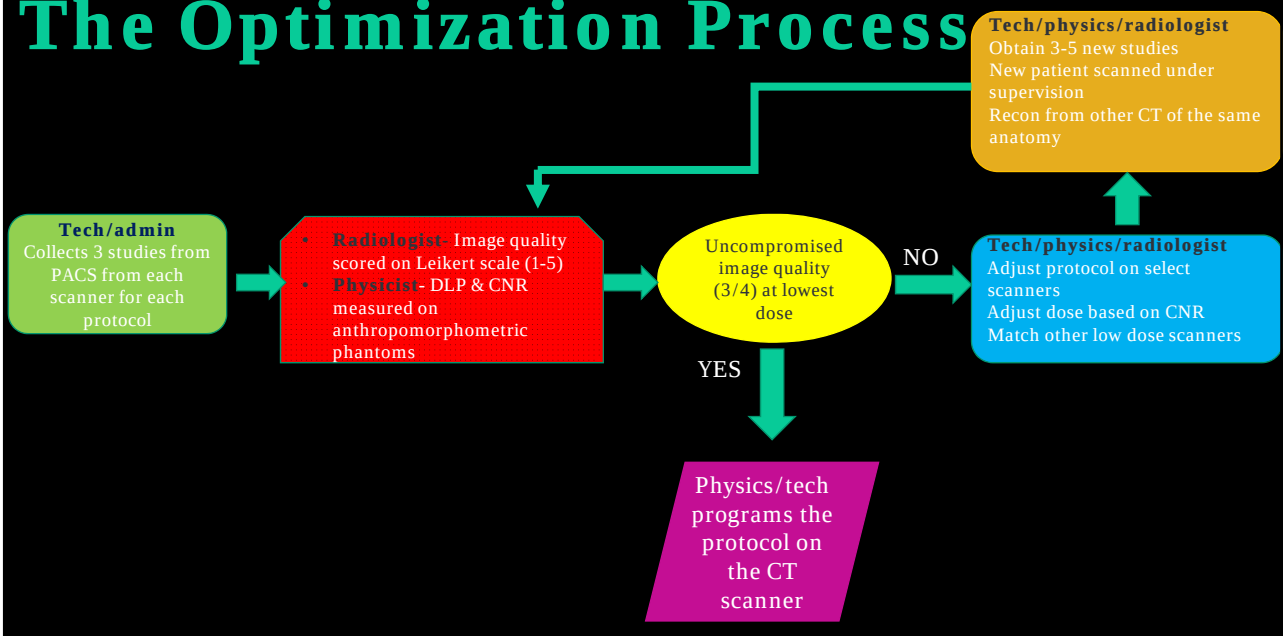
The Optimization Process

- All existing protocols were reviewed on a divisional basis
- 3 studies selected from the PACS for each protocol from each CT scanner
- Evaluated by a radiologist on a five point Likert scale for image quality (1-5)
- Physicist quantified the radiation dose (DLP) and image quality (CNR) using anthropomorphic phantoms
- If the image quality was maintained at the lowest dose, that protocol was programed in the scanner.

The Optimization Process

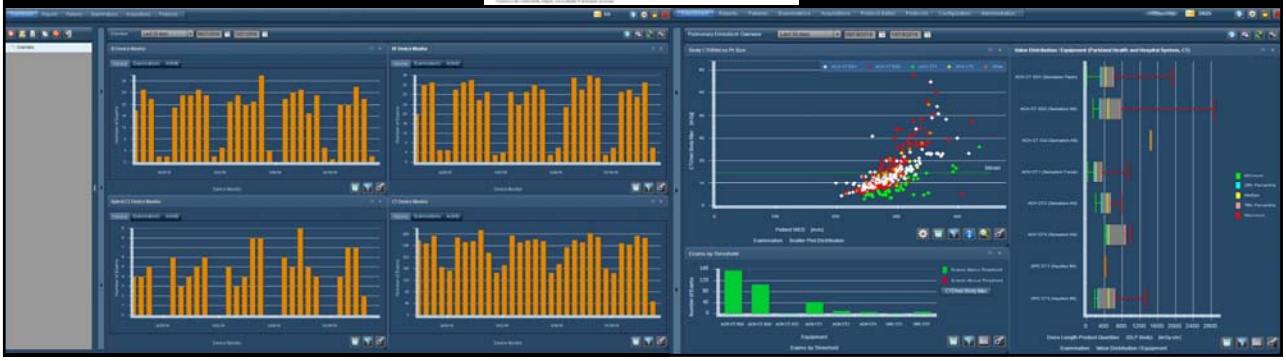
- If the image quality was not maintained at the lowest dose, the protocol was optimized based on CNR metrics and previously optimized CT protocols
  - Acquisition parameters
  - Reconstruction kernels
  - Iterative reconstruction levels
- The review process was repeated with the proposed protocol.
- The lowest dose which did not compromise image quality was selected
- Redundant protocols were also eliminated, merging protocols which could give similar results- *Eg- Bony pelvis from CT abdomen, pelvis; Lumbar spine from CT abdomen*

The Optimization Process



Radiation dose storage

- Radiation doses were tracked consistently and stored in a database
- Radimetrics was utilized to store, retrieve and analyze the radiation dose programs



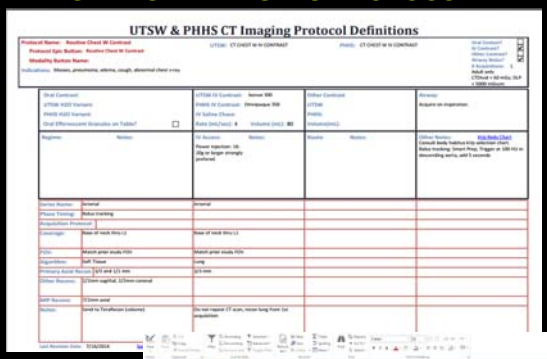
Protocol homogenization

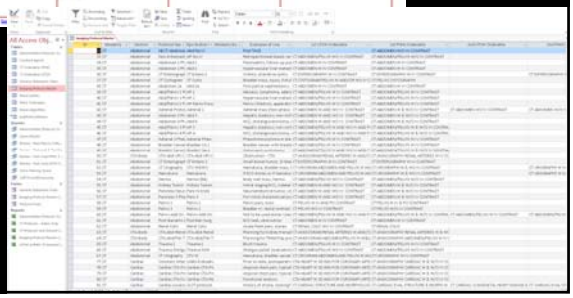
- Imaging protocol was defined across subspecialty radiologist teams
- Each protocol was reviewed by subspecialty radiologist groups
- Overlapping protocols combined
- Duplicated/outdated protocols eliminated
- New protocols developed if there was a clinical requirement
- Imaging protocols reflect specific modalities and available equipment
- After consensus, pdf document of protocol created

Protocol homogenization

- Database created linking clinical imaging protocols to scanner/machine specific acquisition parameters
- Implemented in Microsoft Access
  - Contrast administration
  - Imaging phases
  - Radiation dose
  - Electronic orders

CLINICAL IMAGING PROTOCOL

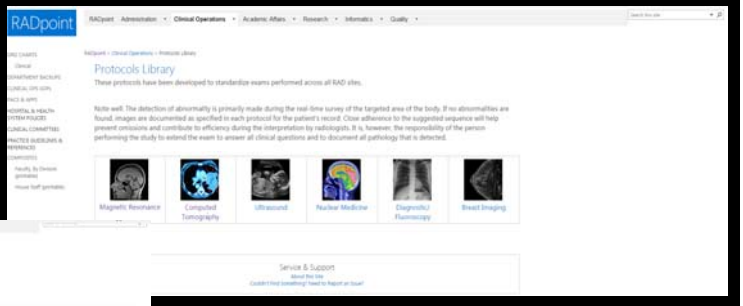


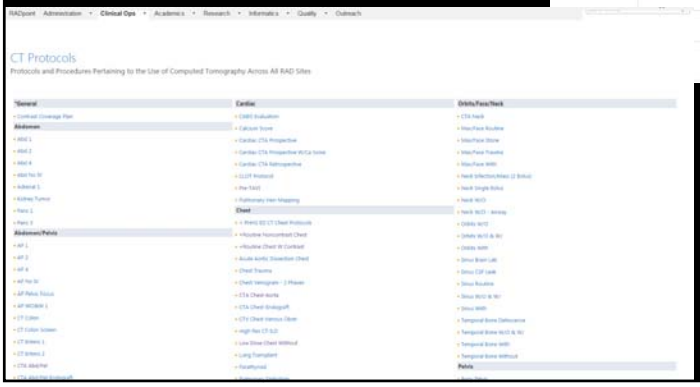


LINK BETWEEN CLINICAL AND MACHINE PROTOCOLS

Protocol storage

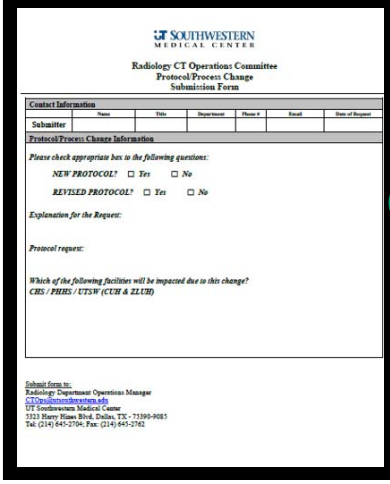
- Protocol library was made available to everybody regardless of location
- Sharepoint site or “Radpoint’
- “Source of truth” for all protocols
- Protocol pdf documents stored





Protocol change process

- A "Protocol Czar" was tasked to manage protocol change process
- Standard process established to manage protocol change process



SOUTHWESTERN MEDICAL CENTER

Radiology CT Operations Committee
Protocol/Process Change
Submission Form

Contact Information

	Name	Title	Department	Phone #	Email	Date of Request
Submitter						

Protocol/Process Change Information

Please check appropriate box to the following questions:

NEW PROTOCOL? ☐ *Yes* ☐ *No*

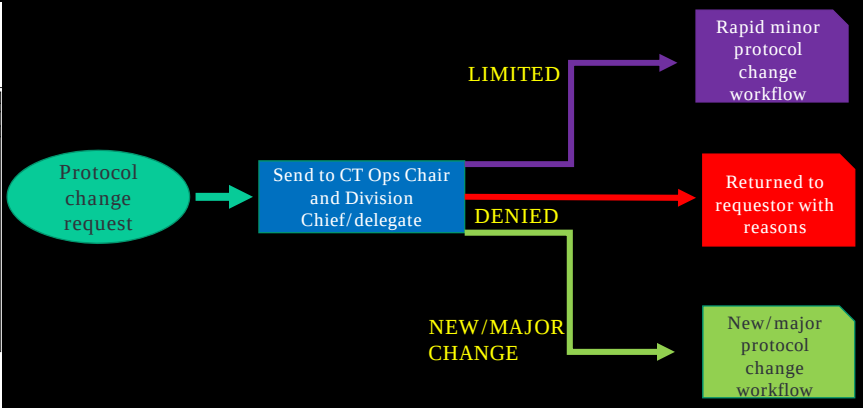
REVISED PROTOCOL? ☐ *Yes* ☐ *No*

Explanation for the Request:

Protocol request:

Which of the following facilities will be impacted due to this change?
CBS / PBHS / UTSW (CUH & ZLUH)

Submit form to:
Radiology Department Operations Manager
CTOps@utsouthwestern.edu
UT Southwestern Medical Center
5323 Harry Hines Blvd., Dallas, TX - 75390-9085
Tel: (214) 645-2704; Fax: (214) 645-2762



For further details, please visit QS131-ED-THA2

Results- Protocol homogenization

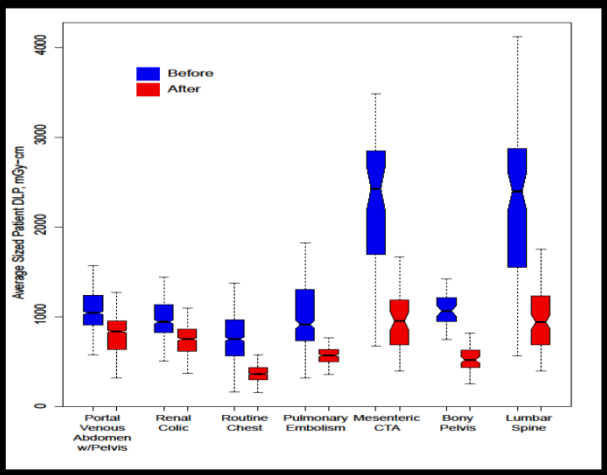
- Project start- May 2014
- Protocols reviewed- >2000 individual scanner protocols
- Optimization proceeded from division to division
- First division (Cardiothoracic) was completed in two months
- Entire optimization process completed in 9 months
- Total number of types of CT protocols decreased from 222 to 136

Results- Radiation dose

- Significant improvements in radiation doses
- Improvements ranging from 23-58 % dose reduction

Results- Radiation dose

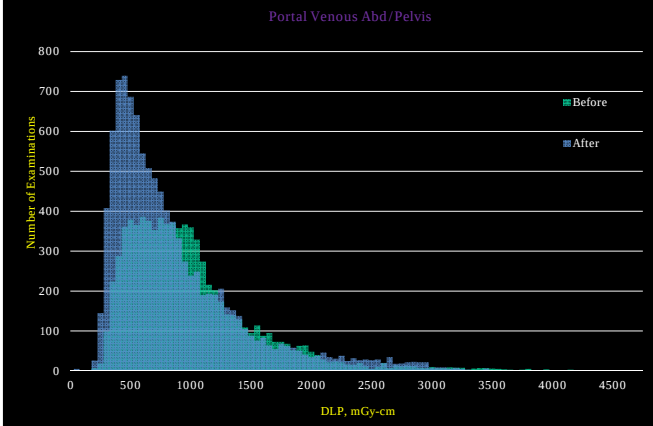
Evaluation of radiation doses for each optimized protocol over a period of one year before and one year aft implementation was done using geometric mean to measure differences in dose



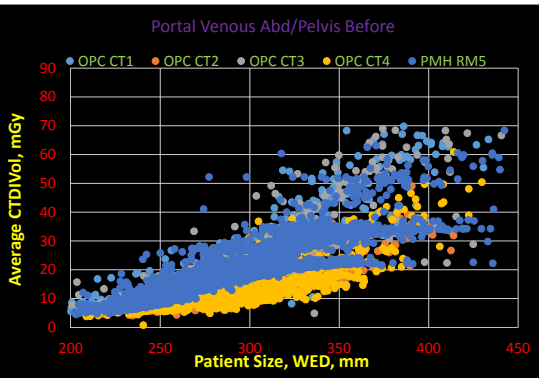
Boxplots showing the radiation doses of average sized patient in 7 protocols, before and after optimization

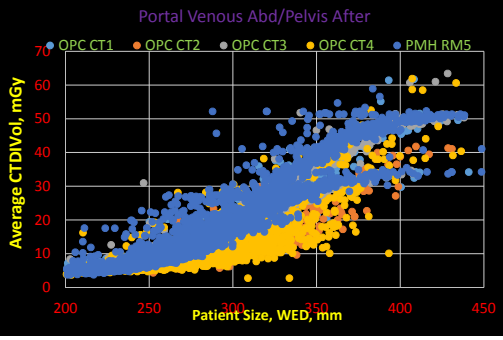
Protocol	Geometric Mean DLP, mGy-cm		Improvement (%)
	Before	After	
Routine abdomen,pelvis	900	690	23
Renal colic	900	660	27
Routine chest	710	400	44
Pulmonary embolism	960	600	38
Mesenteric CTA	1845	975	47
Bony Pelvis	1170	490	58
L-Spine	1850	970	48

Results
Abdomen and Pelvis, portal venous phase

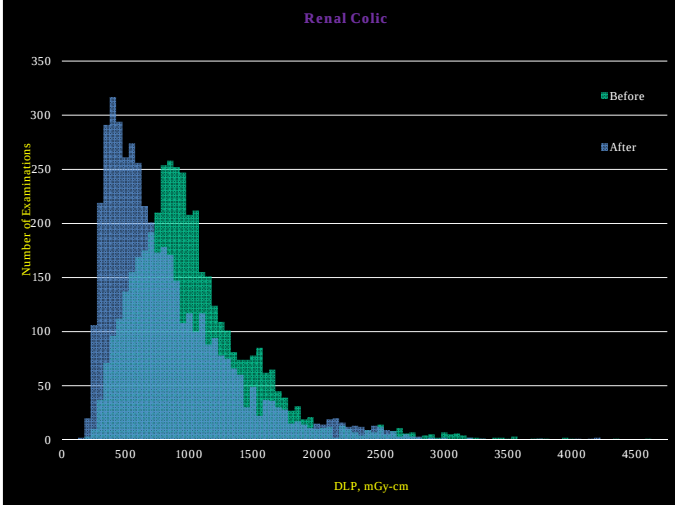


Scatter plot distribution of radiation dose, **before (green)** and **after (blue)**

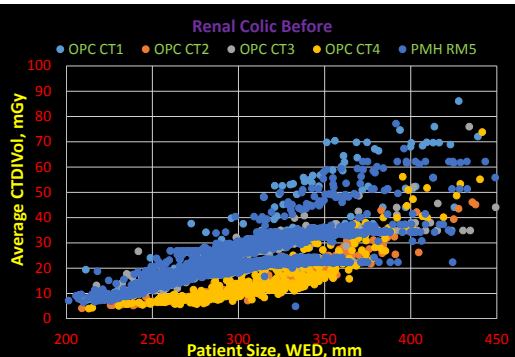


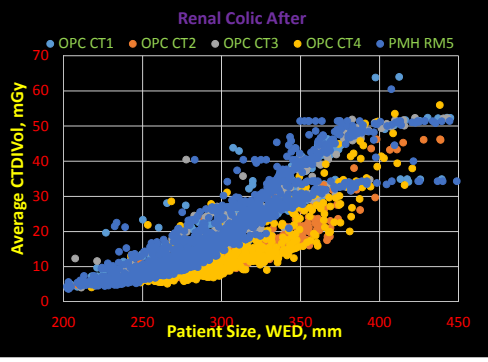


Renal colic

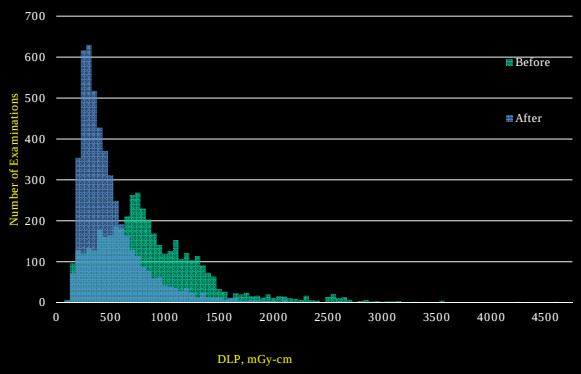


Scatter plot distribution of radiation dose, **before (green)** and **after (blue)**

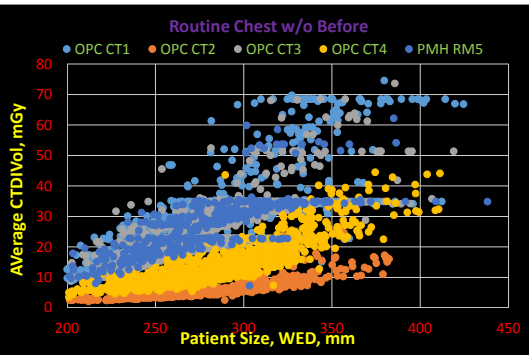


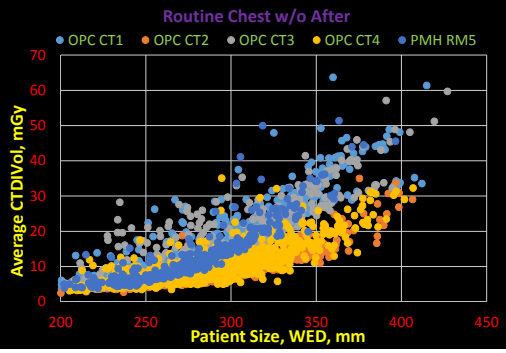


Routine Chest

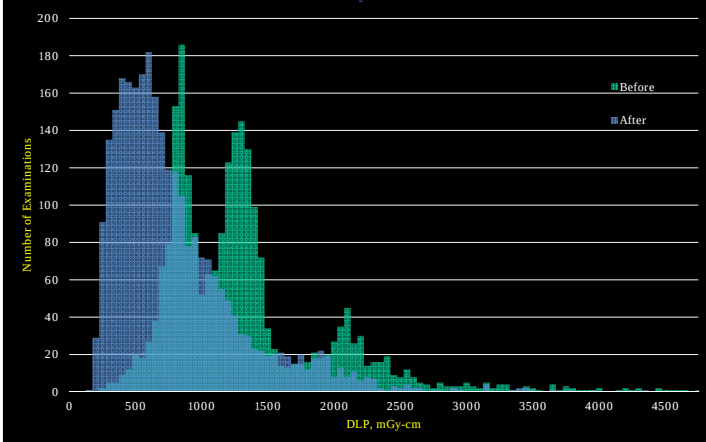


Scatter plot distribution of radiation dose, **before (green)** and **after (blue)**

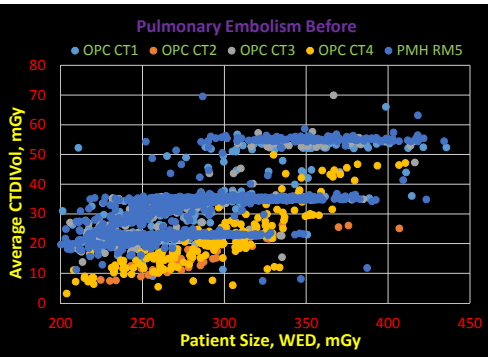


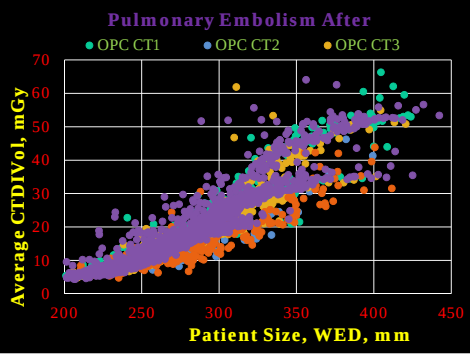


Pulmonary embolism

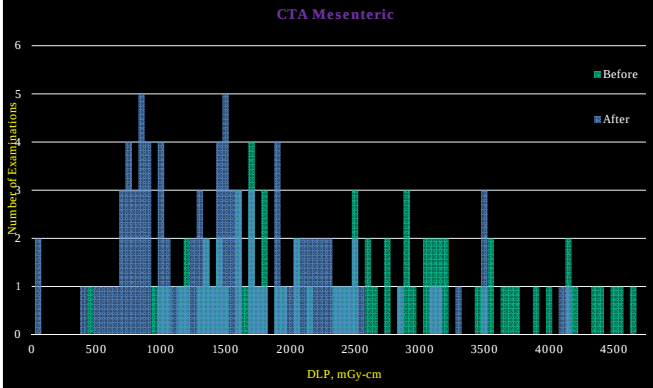


Scatter plot distribution of radiation dose **before (green)** and **after (blue)**

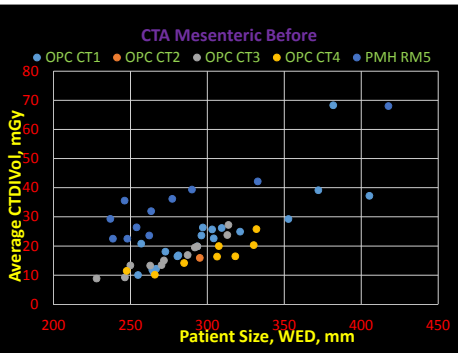


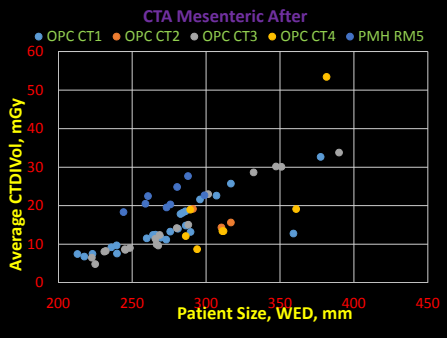


CTA mesenteric

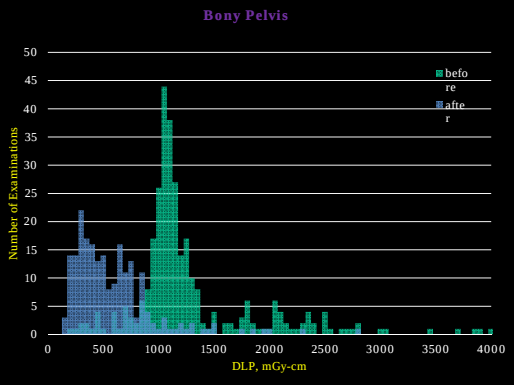


Scatter plot distribution of radiation dose **before (green)** and **after (blue)**

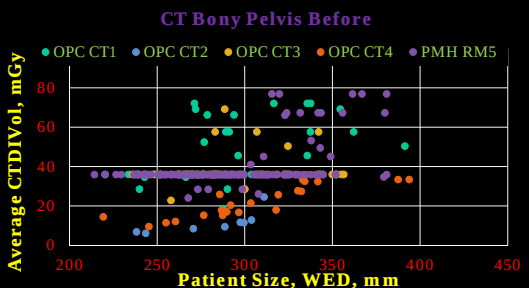


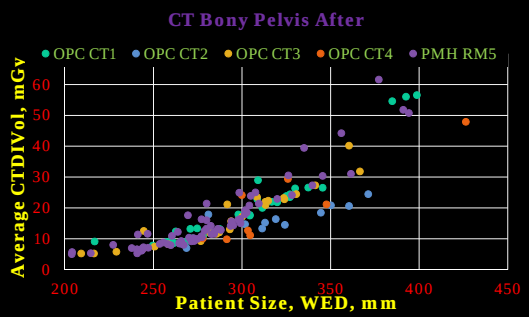


Bony pelvis

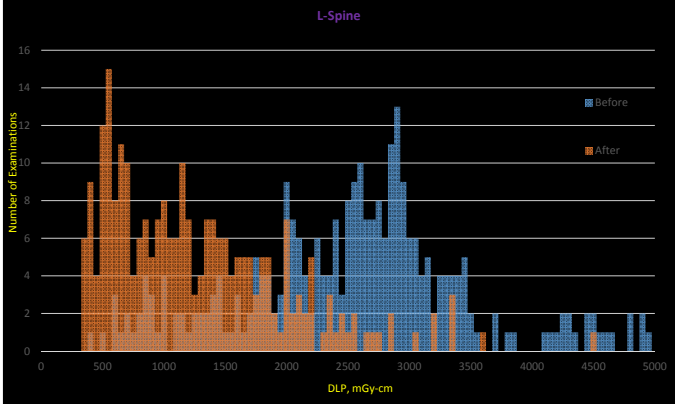


Scatter plot distribution of radiation dose **before (green)** and **after (blue)**

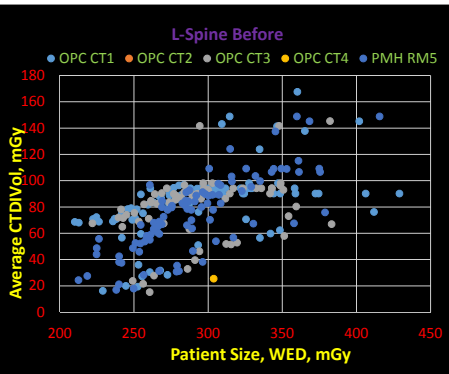


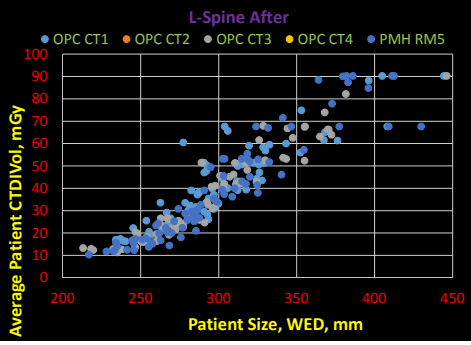


Lumbar spine



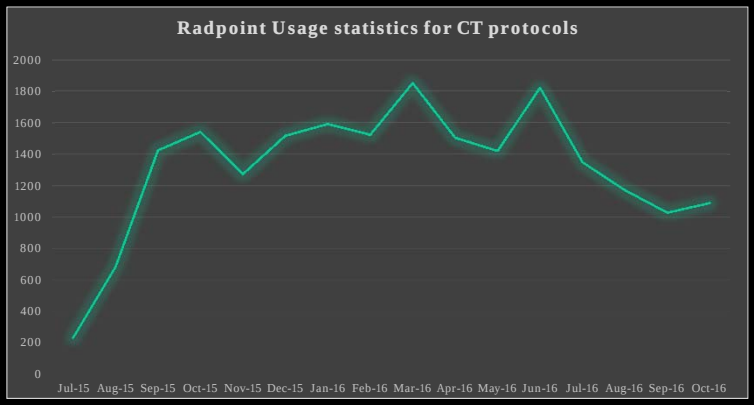
Scatter plot distribution of radiation dose, before (blue) and after (orange)





Results- Protocol Usage

- Protocol access through Radpoint
- Number of CT protocol page visits from July 2015 till date - 21,037
- Average/month - 1315

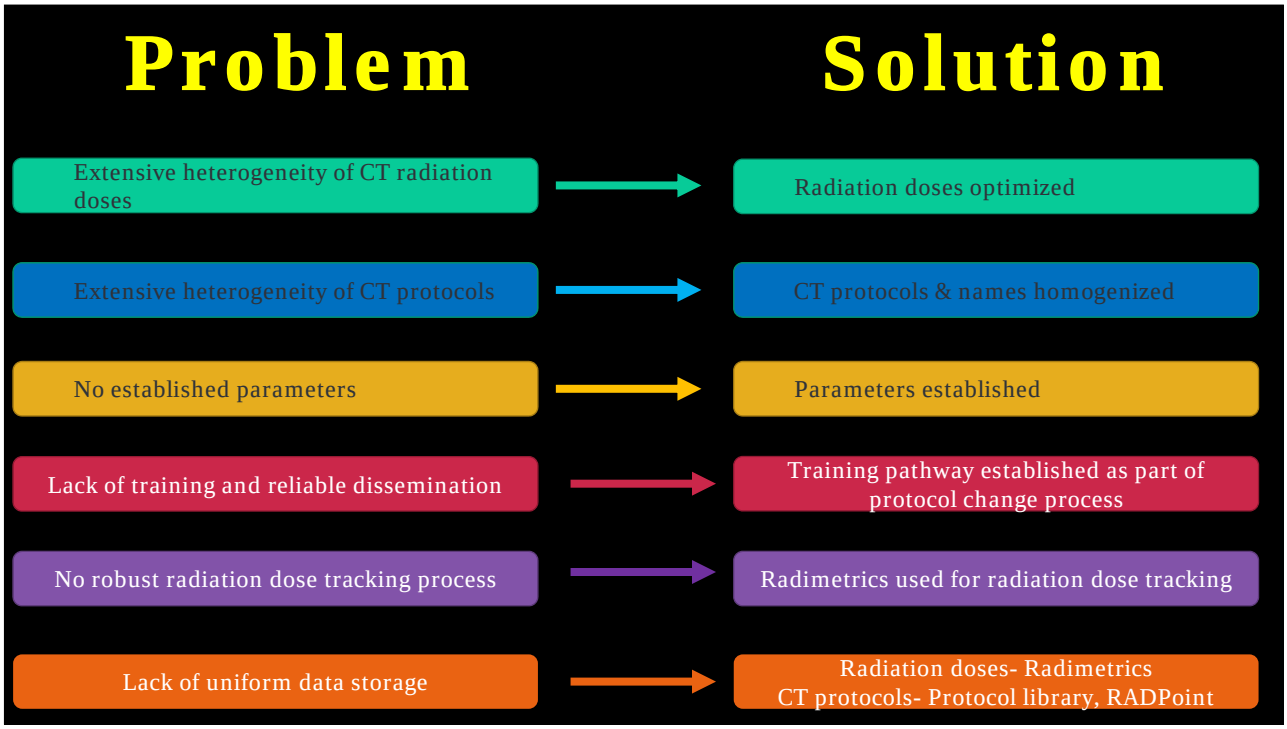


Discussion

- It is possible to establish a robust radiation dose reduction and protocol homogenization program in a complex health system
- Requires participation of all stakeholders, including radiologists, technologists, physicists and hospital administrators
- Each protocol can be optimized by an iterative process that uses both clinical and phantom data

Discussion

- Training of technologists is an important component of the program and we achieved this by incorporating this as a part of protocol change process
- Imaging protocol homogenization requires subspecialty operating committees and specific individuals to manage the process
- Dissemination of protocols was made easy by a novel web-based information distribution system
- Periodic protocol and dose review ensures consistent maintenance of quality



Conclusion

- We successfully managed the complex process of homogenizing CT protocols and optimizing radiation doses without compromising image quality
- Key elements are-
  - Establishment of CT Dose task force and CT operations committee
  - Iterative process of protocol optimization using phantom and clinical tests
  - Novel web-based information distribution system for protocols
  - Establishment of a protocol change process
  - Establishment of radiation dose tracking process