Dose reduction opportunities in MDCT

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AAPM 2020

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OUTLINE

- Reduce unindicated phases
- Fulfill multiple exams with one exposure
- Identify and reduce repeat scanning
- Reduce overlapping scans
- Normalize dose across fleet

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UNINDICATED PHASES

Ionizing Radiation in Abdominal CT: Unindicated Multiphase Scans Are an Important Source of Medically Unnecessary Exposure

Kristie M. Guite, MD[a], J. Louis Hinshaw, MD[a], Frank N. Ranallo, PhD[a,b], Mary J. Lindstrom, PhD[c], Fred T. Lee Jr, MD[a]

Purpose: CT radiation exposure has come under increasing scrutiny because of dramatically increased utilization. Multiphase
important, overlooked

Results: A total of 978 phases were performed in 500 patients; 52.8% (264 of 500) received phases that were not supported by ACR criteria. Overall, 35.8% of phases (350 of 978) were unindicated, most commonly being delayed imaging (272 of 350). The mean overall total radiation effective dose per patient was 25.8 mSv (95% confidence interval, 24.2-27.5 mSv). The mean effective dose for unindicated phases was 13.1 mSv (95% confidence interval, 12.3-14.0 mSv), resulting in a mean excess effective dose of 16.8 mSv (95% confidence interval, 15.5-18.3 mSv) per patient. Unindicated radiation constituted 33.3% of the total radiation effective dose in this population. Radiation effective doses exceeding 50 mSv were found in 21.2% of patients (106 of 500).

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UNINDICATED PHASES

- CMS Imaging Efficiency Measures
  - Use of Abdomen CT with and without contrast except for specific indications
  - Use of Thorax CT with and without contrast except for specific indications
  - Performing Brain CT and Sinus CT on the same day except for specific indications

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UNINDICATED PHASES

Use of Abdomen CT with and without contrast

Abdomen CT—Use of Contrast Material (OP-10)

2019 Annual Reevaluation Report

Produced by
Yale-New Haven Health Services Corporation/Center for Outcomes Research and Evaluation (YNHHSC/CORE)
The Lewin Group

Prepared for
Centers for Medicare & Medicaid Services (CMS)
Contract Number: HHSM-500-2013-13018I, Task Order: HHSM-500-T0002
Option Period Four

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UNINDICATED PHASES

Abdomen CT—Use of Contrast Material (OP-10)

2019 Annual Reevaluation Report

- This looks only at Medicare outpatients
- Excludes diagnoses for which scanning w/ and w/o contrast is indicated
  - Adrenal mass, liver lesion, pancreatic disorder, etc.

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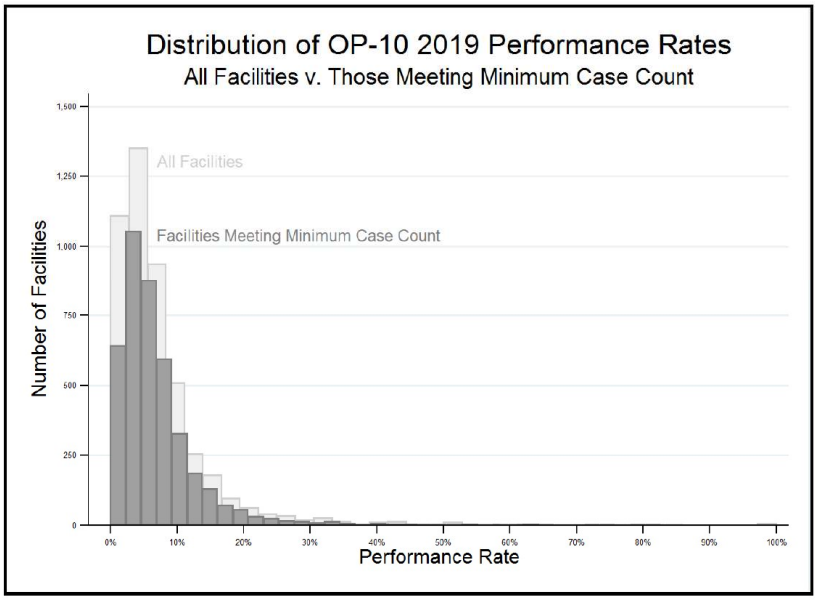
Figure 2: **Distribution of 2019 OP-10 Performance Rates, Comparing the Distribution for All Facilities v. Those Meeting Minimum Case Count**



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UNINDICATED PHASES

- Other metrics:
  - Chest CT with and without contrast
  - Same day brain and sinus exams
- These have very low rates by 2019 (median ~1%) so are being removed from CMS Hospital Outpatient Quality Reporting in 2021

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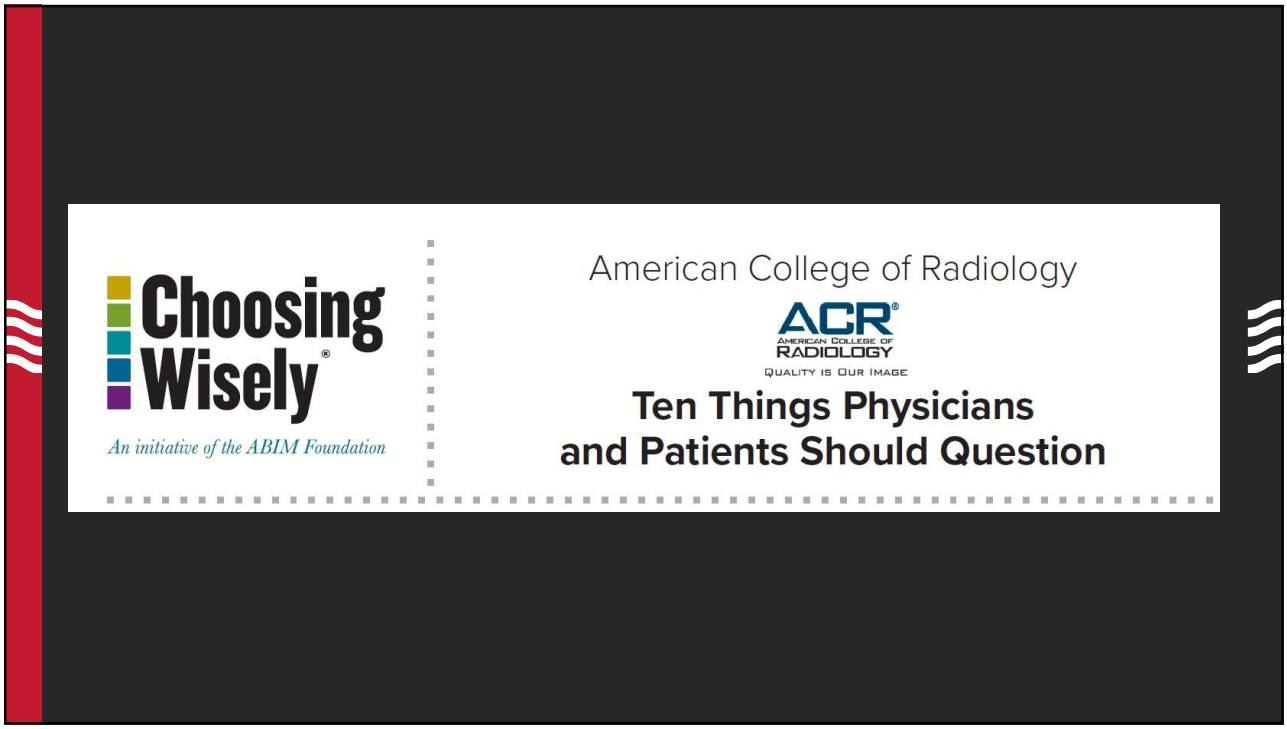

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Don't use a protocol for abdominal CT that includes unenhanced CT followed by IV contrast-enhanced CT, except for the following indications: renal lesion characterization, hematuria work up, indeterminate adrenal nodule characterization, follow-up after endovascular stent repair, gastrointestinal hemorrhage or characterizing a focal liver mass.

With the goal of modulating patient radiation exposure and costs, IV contrast enhanced multidetector CT (MDCT) protocols should include an unenhanced acquisition only if it will provide additional diagnostic information. In conjunction with IV contrast enhanced abdominal MDCT, the literature supports an unenhanced acquisition for the following indications:

(1) Renal lesion characterization or hematuria work up
   a. Compare unenhanced with post-contrast to identify enhancement in a mass

(2) Adrenal nodule characterization
   a. IV contrast phases are not necessary if nodule measures <10 Hounsfield units (HU) on unenhanced CT.
   b. If ≥ 10 HU, unenhanced attenuation is used to calculate percentage washout.

(3) Endovascular stent evaluation
   a. Unenhanced scan enables distinction of calcification from endoleak when compared to post-contrast images

(4) Gastrointestinal bleeding
   a. Unenhanced CT enables definitive distinction of intraluminal hemorrhage from other high-density material (i.e., medication, fecal matter); however, protocols that use only arterial and venous phase acquisitions may be sufficient, as hemorrhage changes configuration between the 2 phases.
   b. If available, dual energy can be used to create a virtual unenhanced dataset and avoid the unenhanced acquisition.

(5) Focal liver mass
   a. Compare unenhanced with post contrast to identify enhancement in a mass

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Don't routinely use a protocol for abdominal CT that includes a delayed post-contrast phase after the venous phase, except for the following indications: renal lesion characterization, hematuria work up, CT urogram, indeterminate adrenal nodule characterization, hepatocellular carcinoma and cholangiocarcinoma.

With the goal of modulating patient radiation exposure, IV contrast enhanced multidetector CT (MDCT) protocols should include a delayed post contrast acquisition (defined as an acquisition after the portal venous, hepatic or nephrographic phases) only if it will provide additional diagnostic information. The literature supports an additional delayed acquisition for the following indications:

(1) Renal lesion characterization, hematuria work up or CT urogram
   a. contrast enhancement pattern of solid renal mass over time provides diagnostic information about pathologic subtype
   b. delayed phase defines relationship of solid renal mass relationship to collecting system
   c. delayed phase facilitates identification of transitional cell carcinoma and traumatic injury

(2) Adrenal nodule characterization
   a. delayed attenuation used to calculate Absolute Percentage Washout and Relative Percentage Washout

(3) Hepatocellular carcinoma
   a. multiple acquisitions facilitate lesion detection and washout characterization

(4) Cholangiocarcinoma
   a. enhancement increases over time, justifying use of delayed in patients where distinction between cholangiocarcinoma and HCC is required.

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UNINDICATED PHASES

- Work with your radiologists to identify protocols which likely include unindicated phases and work to correct
- Educate techs about changes
- At the very least: routine abdomen should not have with and without contrast
- Potential to approx. half the dose of the exam

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School of Medicine and Public Health
UNIVERSITY OF WISCONSIN-MADISON

UW Quick Protocolling Guide

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Body Protocol Quick Guide

REF Rev: 2.0

When in doubt, please ask/double check/call referring provider!

Indication(s)	Protocol	Oral Contrast Type
RCC, NET (hypervascular mets)	Biphasic abdomen, routine pelvis	Water
Cancers with possible hep met disease. (EXCEPTIONS: Not for lymphoma, testicular ca, RCC/NET, prostate ca, discuss in young pts)	High quality cancer follow up	Positive Contrast, see protocol
Cirrhosis, HCC	R/o HCC	Water
Cirrhosis, eval for transplant	Liver Transplant recipient work up	Water
Possible liver donor	Liver donor workup	Water
Pre liver resection, post transplant	Consider triphasic liver	Water
Abdominal pain, Pancreatitis	Routine abdomen/pelvis	Positive Contrast, see protocol
Assess for hernia	Hernia protocol	Positive Contrast, see protocol
Assess for pancreas cancer, assess resectability. (But if known metastatic or unresectable pancreas cancer, see above, high quality cancer follow up)	Pancreas cancer	Water
Pancreas transplant	Consider CTA pancreas tx if requested	Water
Mesenteric ischemia	Mesenteric ischemia (default DECT)	Water

This is free online, google "UW CT Protocols" or https://www.radiology.wisc.edu/uw-ge-ct-protocol-project/resources/

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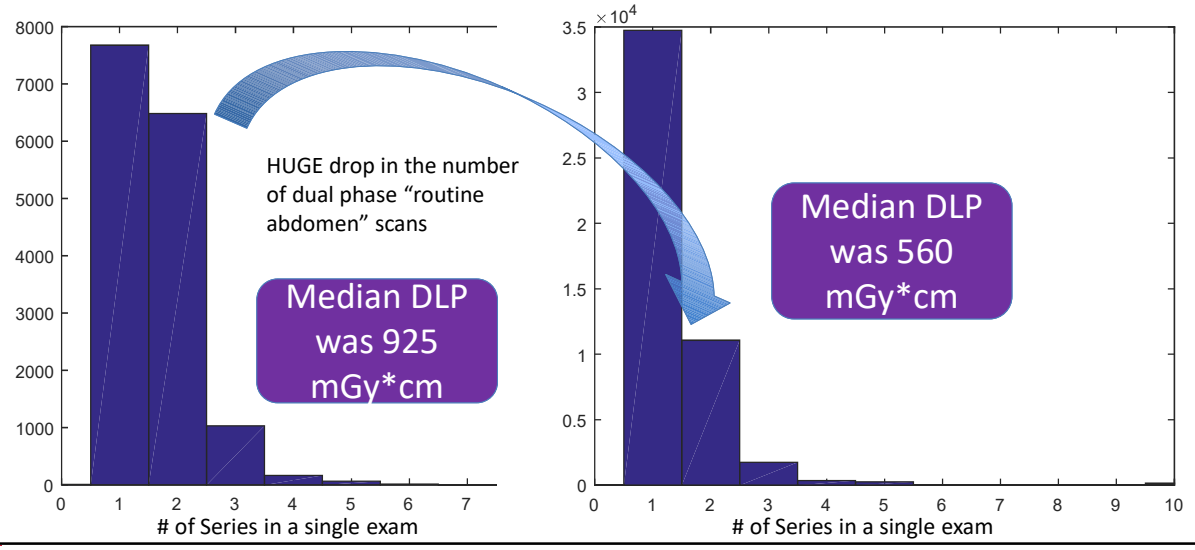
Before and after histograms of series count within "routine abdomen pelvis exams"



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MULTIPLE ORDERS ONE EXPOSURE

- If multiple orders have overlapping scan ranges, they can be can reconstruct from the same exposure
- Examples:
  - Head & sinus & facial bone
  - Trauma abd/pelvis & spine

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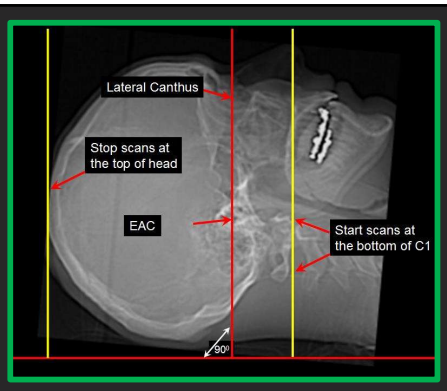

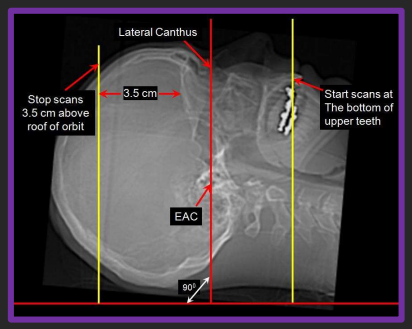

Routine head: start scans at the bottom of C1 and scan through the top of the head
Facial bones: Start just below the mandible to the top of the frontal sinuses
Sinus: Scan from bottom of upper teeth to 3.5 cm above the orbital roof

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MULTIPLE ORDERS ONE EXPOSURE

- Instead of three separate, overlapping exposures – can expose once and reconstruct the other orders from the same data set
- Consider:
  - Dose levels
  - Contrast dynamics
  - Patient positioning
- Potential to reduce the dose to half or more

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REPEAT SCANNING

- Types of CT repeats:
  - Localizer
  - Bolus tracking
  - Overlapping helical/axial scans
  - Extension helical/axial scans
- Causes of CT repeats:
  - Patient motion
  - Poor bolus timing
  - Poor patient positioning
  - Poor image quality (e.g. photon starvation)

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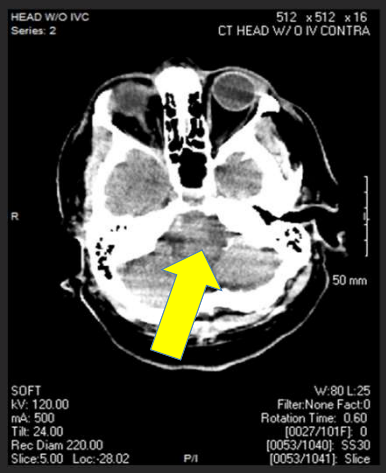
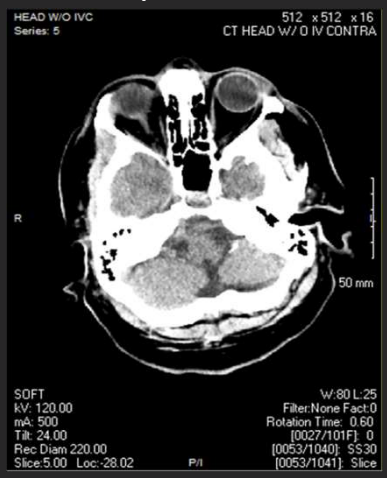
Initial Scan



Repeat Scan



Repeat due to motion

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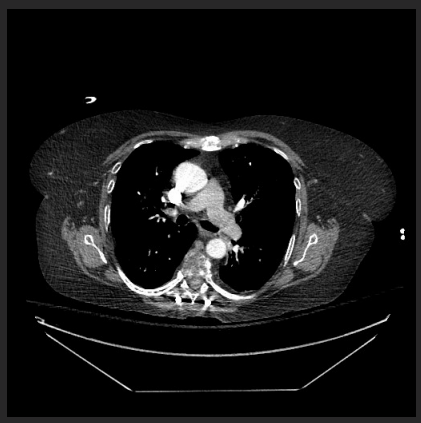
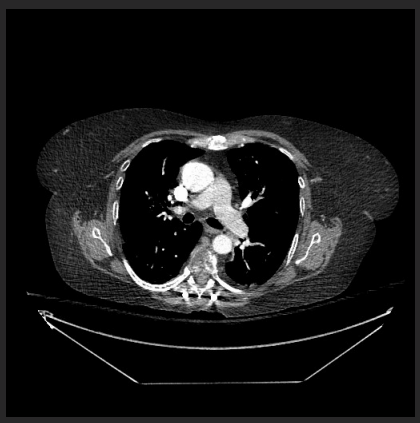
Initial Scan



Repeat Scan



Repeat due to poor bolus

(SVC and aorta have more contrast than PA)

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< Previous Article June 2013 Volume 10, Issue 6, Pages 416–422 Next Article >

Radiology Stewardship and Quality Improvement: The Process and Costs of Implementing a CT Radiation Dose Optimization Committee in a Medium-Sized Community Hospital System

Jenifer R.Q.W. Siegelman, MD, MPH[a,b,*], Dustin A. Gress, MS[c]

PlumX Metrics
DOI: https://doi.org/10.1016/j.jacr.2012.12.008
Article Info

Results

Over 3 months, the committee met in person twice and exchanged 128 e-mails in establishing a process for protocol improvement and measurement of success. Repeat rate was reduced from 13% (13 of 100) to 0% (0 of 100). Scans meeting the ACR reference level for CTDIvol (75 mGy) improved by 34% (38 of 100 before, 51 of 100 after; Fisher's exact 2-tailed $P = .09$), and those meeting ACR pass/fail criterion (80 mGy) improved by 29% (58 of 100 before, 75 of 100 after; Fisher's exact 2-tailed $P = .01$). Committee evolution and work, and protocol development and implementation, required 57 person-hours, at an estimated labor cost of $12,488.

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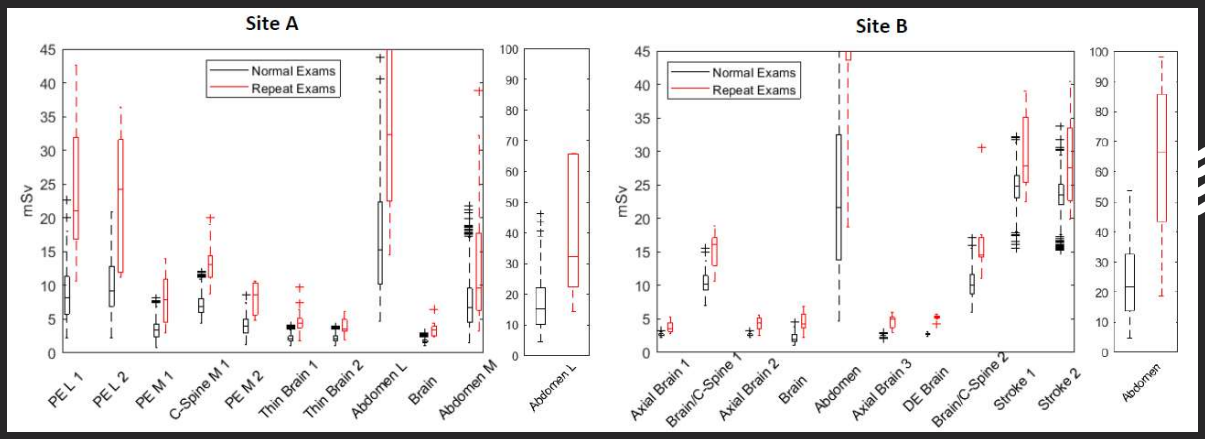
REPEAT SCANNING



Rose…Szczykutowicz 2020 In Press American Journal of Roentgenology "A multi-institutional study on wasted scans from 60,000 patients in CT"
Szczykutowicz and Rose "First Look: Repeat Rates in CT". Radiology Management Sep./Oct. 2019 41(5)

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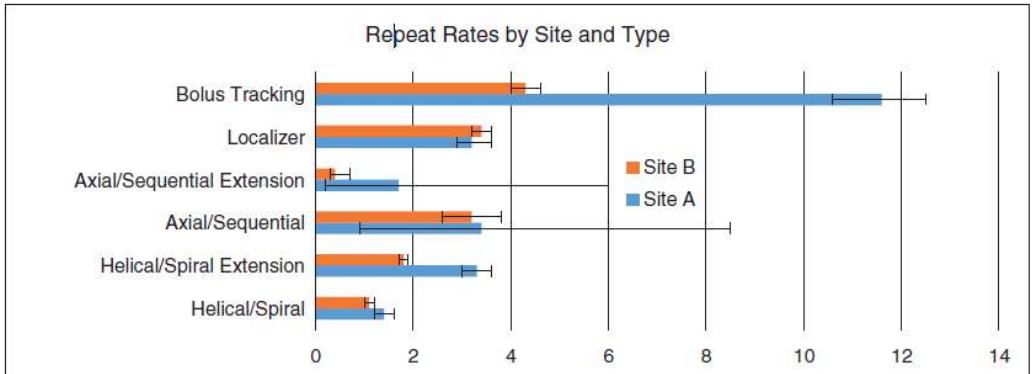

	Helical/Spiral	Helical/Spiral Extension	Axial/Sequential	Axial/Sequential Extension	Localizer	Bolus Tracking
Site B	1.1	1.8	3.2	0.4	3.4	4.3
Site A	1.4	3.3	3.4	1.7	3.2	11.6

Rose…Szczykutowicz 2020 In Press American Journal of Roentgenology "A multi-institutional study on wasted scans from 60,000 patients in CT"
Szczykutowicz and Rose "First Look: Repeat Rates in CT". Radiology Management Sep./Oct. 2019 41(5)

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REPEAT SCANNING

- Can manually track repeats
- Once pattern of repeats known – can begin to intervene
  - Contrast administration
  - Patient positioning
  - Patient instructions
  - Tech's scan prescription

…All with the goal of decreasing repeat rates and thus reducing unnecessary dose

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OVERLAPPING SCANS

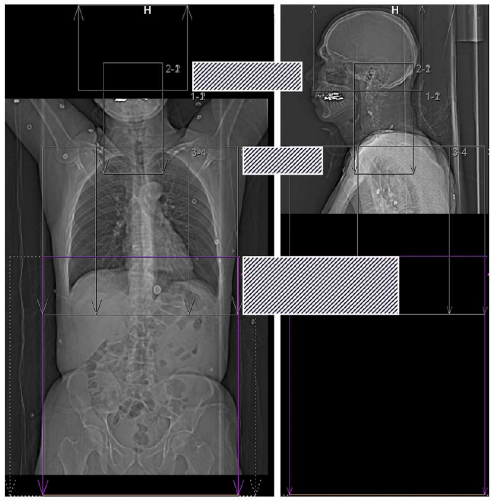

Fig. 5. Overlap between adjacent scan regions in a trauma pan-scan of the head, cervical spine, chest, abdomen, and pelvis. Thin-line boxes denote separately prescribed scan parts, with arrows indicating the direction of scanning. Crosshatched regions indicate areas of overlap that may be reduced with technologist directives or protocol modifications that combine adjacent parts into a single scan.

- This represents duplicate images for radiologist to read
- Unnecessary dose

A. Sodickson, Strategies for Reducing Radiation Exposure in Multi-Detector Row CT, Radiol. Clin. North Am. **50**(1), 1–14 (2012).

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OVERLAPPING SCANS

- Scan what is clinically appropriate
- Consider combining Chest and Abd/Pel
  - Contrast phase
  - Speed/image quality
- Dose reduction potential is less here than previous methods, but can still save 10's of %

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NORMALIZE DOSE ACROSS FLEET

- Dose monitoring software is widely available
- Look at the same protocol on each scanner
  - Should have similar doses for the same protocol
  - Correct for different patient populations, if applicable

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NORMALIZE DOSE ACROSS FLEET

Full Paper

Variations in radiation dose between the same model of multislice CT scanner at different hospitals

C J Koller[1], MSc, J P Eatough[1], PhD, and A Bettridge[2], DCR(R)

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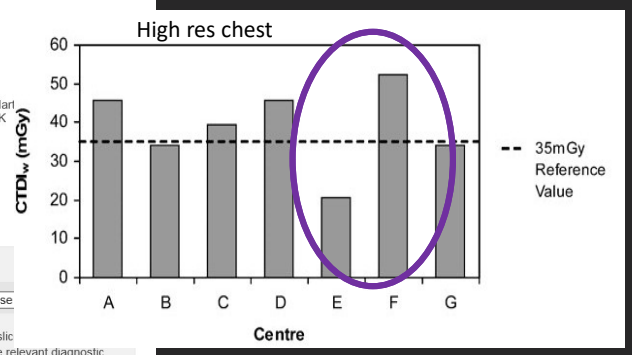
ST4 7LN and [2]X-ray Department, Queens Hospital, Belvedere Road, Burton-on-Trent ST16 3SA, UK

https://doi.org/10.1259/bjr/33117342
Received: October 22, 2002
Accepted: June 10, 2003
Published Online: February 13, 2014

ABSTRACT FULL TEXT FIGURES REFERENCES CITED BY PDF PDF PLUS

ABSTRACT SECTION: Choose

The variation in exposure factors and patient dose, between seven centres using identical multislic
investigated for six standard examinations. Dose values were compared with each other and the relevant diagnostic
reference level (DRL) for each examination. The range in weighted CT dose index ($CTDI_w$) values between the seven



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NORMALIZE DOSE ACROSS FLEET

- Modify protocols as needed to match dose levels
- Might find protocoling issue
- This requires a little more detailed work
- Potential to reduce dose by 10's of %

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OUTLINE

- Reduce unindicated phases
- Fulfill multiple exams with one exposure
- Identify and reduce repeat scanning
- Reduce overlapping scans
- Normalize dose across fleet

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THANK YOU

UW Madison colleagues

- Tim Szczykutowicz
- Sean Rose

Thank you for your attention

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