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Assessing CT Image Quality and Matching Protocols Across Vendors

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Relevant Conflicts of Interest

No Relevant Conflicts

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Why Do Protocols Vary?

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Why Do Protocols Vary?

- **Old technology**
- **Vendor implementation**
- **"Pseudo-modalities"**

Old vs. New Technology

impact of the detector change on absolute CT values of a calibration phantom was observed. Spatial resolution was improved by more than 10% for the solid-state system. As the system's modulation transfer functions were measured with a wire phantom and otherwise unchanged scanner geometry and image reconstruction algorithm, the increase of resolution is explained by the improved temporal response of the solid-state detector. At the same time, noise was reduced by 12% for a 20-cm diameter water phantom. The noise reduction corresponds to a possible reduction of patient dose by 23% for constant image quality, which is in good agreement with our prediction by estimations of both

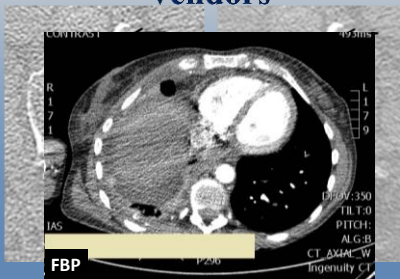IEEE TRANSACTIONS ON MEDICAL IMAGING, VOL. 19, NO. 9, SEPTEMBER 2000
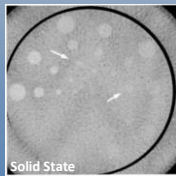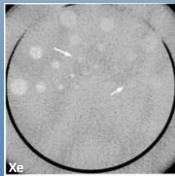
Xe   Solid State

Vendors
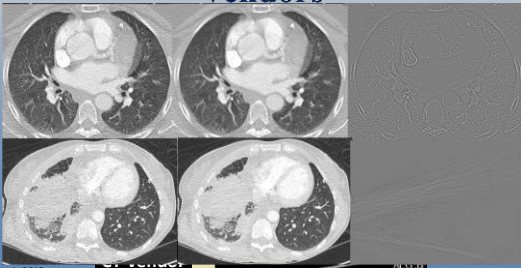

FBP

Vendors
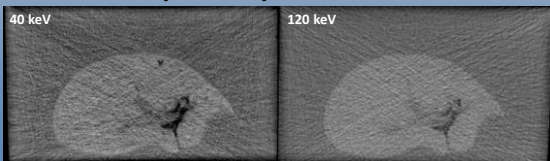

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Vendors

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New Pseudo-Modalities

- **Virtual non-contrast . . . Ok**
- **Mono/Mixed Energies? . . . Maybe**
- **Iodine map? No equivalent**

40 keV   120 keV

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Why Match Protocols?

- **Physicians like consistency**
  - **Flow**
  - **Comfort**
  - **Ability**
- **Reduce variability in "Image Quality"**

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Why Match Protocols?
Not Necessarily:
Best Image
Best Dose
"Optimized" as an individual machine

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How can we reduce variability?

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Match Dose

- **Not ideal. . .**
- **Not a bad start**
- **Fast**
- **Practical**
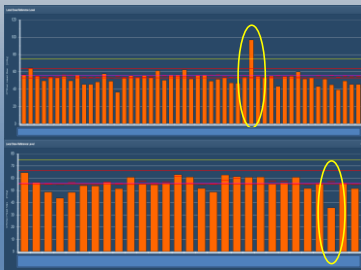

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Match Dose

- **Assumes**
  - **Technology is about the same**
  - **Non-dose parameters are comparable**

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Match Subjective Quality

- **Clinical-ish**
- **Quantitative-ish?**
- **Not just dose**
- **Fast-ish?**

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What is Image Quality?

- **Is this good image quality?**
  - **Yes**
  - **No**
  - **Need more info**
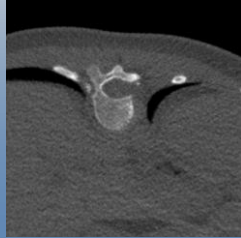
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Fast and Dirty

- **Section chief says ok or not**
- **Great for issues that are not subtle**
- **Great initial step**

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Research-ish

- **Complaint verified by section chief**
- **1+ Radiologists rate**
- **Alter Protocol**
- **1+ Radiologists rate**

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Ratings

- **Contrast?**
- **Resolution?**
- **Noise?**
- **SNR?**

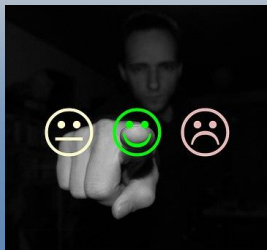- **Sufficient Grey-White differentiation?**
- **Malleus and the incus visible and well defined?**
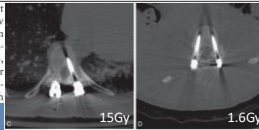
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Ratings Example

TABLE 4. Image Quality Assessment						
BMI	Standard Protocol		Low-dose Protocol		'Significance (Standard *vs.* Low-dose)	
	Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative
<25	3.3 ± 0.7	3.2 ± 0.7	3.8 ± 0.8	3.1 ± 0.8	0.45	0.52
25–35	3.8 ± 0.8	3.7 ± 0.8	4.2 ± 0.8	3.3 ± 0.5	0.34	0.37

BMI indicates body mass index.
'Wilcoxon rank-sum test.

Task-based image quality was assessed using a Likert scale: 0, unsuitable for the task; 1, suitable for task with low confidence in findings; 2, suitable for task with medium confidence in findings; 3, suitable for task with high confidence in findings (nondiagnostic for soft-tissue reading); 4, suitable for diagnostic soft-tissue reading; and 5, suitable for diagnostic soft-tissue reading with high confidence in findings. Although the same scale is used for assessing both

15Gy   1.6Gy

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Image Quality Metrics

- **Contrast**
- **Noise**
- **CNR**
- **MTF**
- **NPS**

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What is in the Literature?

CT protocol management: simplifying the process by using a master protocol concept

Timothy P. Szczykutowicz,[1,2,3a] Robert K. Bour,[1] Nicholas Rubert,[2] Gary Wendt,[1] Myron Pozniak,[1] Frank N. Ranallo[1,2]

$$mA_{new\ master} = mA_{original}\ \frac{t_{original}}{t_{new\ master}}\frac{P_{new\ master}}{P_{original}}\ F_{kV}\,F_{D}\,F_{G}$$

Fig. 4. Flowchart detailing the proper use of mA data and Eqs. (1) and (2) in creating protocols on the same scanner at different CNR levels and customizing these protocols to a different scanner.

- $\sigma = 0$.

	80 kVp	100 kVp
A_{kVp}	1.08	1.02
$A_{Anatomy}$	Med. 1.00	Lung 0.69
A_{Kernel}^2	Soft 0.81	Standar 1.00
	Lung 3.96	Bone 3.34
$A_{algorithm}$	FBP 1.00	30% AS 0.94

$y = 1.2543x$
$R^2 = 0.99602$

Noise (HU) vs Q (emAs)

Mediastinum Noise (HU)

Figure 17: (a) Idealized and (b) actual images of the high contrast resolution and low contrast resolution sections of the ACR phantom for standard-sharp Siemens kernels with (c) their respective NPS.

Figure 15: (a) Idealized and (b) actual images of the high contrast resolution and low contrast resolution sections of the ACR phantom for standard GE kernels with (c) their respective NPS.

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A Strategy for Matching Noise Magnitude and Texture Across CT Scanners of Different

Makes and Models

by

Justin Bennion Solomon

Table 5: Closest matching Siemens kernel for a given GE kernel

GE	Siemens	Minimum RMSE (mm²)	Minimum |PFD| (mm⁻¹)
SOFT	B35f	0.02	0.01
STANDARD	B43f	0.02	0.00
DETAIL	B46f	0.07	0.01
CHEST	B46f	0.04	0.01
LUNG	B80f	0.06	0.01
BONE	B75f	0.35	0.15
BONE+	B75f	0.36	0.15
EDGE	B75f	0.62	0.45

Table 6: Closest matching GE kernel for a given Siemens kernel

GE	Siemens	Minimum RMSE (mm²)	Minimum |PFD| (mm⁻¹)
B10f	SOFT	0.23	0.09
B30f	SOFT	0.23	0.09
B20f	SOFT	0.15	0.06
B22f	SOFT	0.06	0.02
B23f	SOFT	0.05	0.02
B25f	SOFT	0.11	0.04
B26f	SOFT	0.15	0.06
B30f	SOFT	0.06	0.02
B31f	STANDARD	0.06	0.01
B35f	SOFT	0.02	0.01
B36f	SOFT	0.05	0.00
B40f	SOFT	0.03	0.01
B41f	STANDARD	0.05	0.01
B43f	STANDARD	0.02	0.00
B45f	STANDARD	0.11	0.02
B46f	CHEST	0.04	0.01
B50f	CHEST	0.17	0.02
B60f	LUNG	0.22	0.05
B70f	LUNG	0.20	0.05
B75f	LUNG	0.20	0.04
B80f	LUNG	0.06	0.01

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Practical experiences in the transfer of clinical protocols between CT scanners with different ATCM systems

To cite this article: Supawitoo Sookpeng et al 2017 J. Radiol. Prot. 37 84

Table 5. Recommended noise reference settings for Toshiba and GE ATCM systems[a]. Values in brackets can be used for procedures where noisier images can be accepted.

Patient size	Toshiba—target noise	GE—noise index	Corresponding QRM and CTDIvol for Siemens
Small	7.5 (10, 12.5)	8.68 or dose step = +5 (9.26, 9.83)	250 , 6.5 mGy
Average	10 (12.5, 15)	10.41 or dose step = +2 (10.99, 11.57)	250, 9 mGy
Large	12.5 (15, 20)	12.15 or dose step = −1 (12.73, 13.31)	250, 13.2 mGy

[a] Recommended values of the maximum and minimum tube currents for Toshiba and GE are 10–300 mA and 10–450 mA to avoid un-modulated tube current for the sections 2–4.

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A cross-platform survey of CT image quality and dose from routine abdomen protocols and a method to systematically standardize image quality

Christopher P. Favazza, Ph.D.[1], Xinhui Duan, Ph.D.[1], Yi Zhang, Ph.D.[1], Lifeng Yu, Ph.D.[1], Shuai Leng, Ph.D.[1], James M. Kofler, Ph.D.[1], Michael R. Bruesewitz, RT(R)[1], and Cynthia H. McCollough, Ph.D.[*,1]   *Phys Med Biol.* 2015 November 7; 60(21): 8381–8397.

[1]Department of Radiology, Mayo Clinic, Rochester, MN

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Methods for CT Automatic Exposure Control Protocol Translation between Scanner Platforms

Sarah E. McKenney, Ph.D., J. Anthony Seibert, Ph.D., Ramit Lamba, M.D., and John M. Boone, Ph.D.

Department of Radiology, University of California Davis Medical Center, Sacramento, California
J Am Coll Radiol. 2014 March ; 11(3): 285–291.

- **Assume you have a scanner with a protocol you like**

$$\mathcal{E}_{secondary} = \mathcal{E}_{reference} \frac{\left[CTDI_{vol}^{@100 \text{ mAs}} \right]_{reference}}{\left[CTDI_{vol}^{@100 \text{ mAs}} \right]_{secondary}}$$

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The role of informatics

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Optimization Stakeholders

- **JC PC.01.03.01 A26**
  - **A Lead Tech**
  - **An Interpreting Physician**
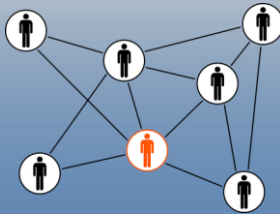 - **A Medical Physicist**
- **. . . err kinda?**

Optimization Stakeholders

- **Who else?**
  - **Imaging Admin**
  - **Lead Tech at each site/region**
  - **Section Chiefs**

Starting Point

- **A good current protocol you trust**
- **Other sources**
  - **AAPM online protocols**
  - ***"Overview of Resources Available for CT Protocol Optimization"***
    - ***amos3.aapm.org/abstracts/pdf/127-35537-418554-127014-425067081.pdf***
  - **CTISUS**
  - **Published Literature**
  - **Etc.**

Optimization Process: Permission

- **Lock down machines**
- **Policy about who can alter protocols**
  - **"This" patient vs. system**
- **Imaging admin buy in**
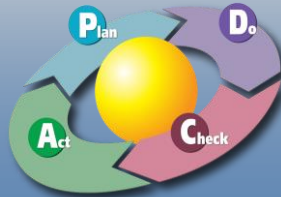 - **No consequence, no care?**

JOIN, or DIE.

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Optimization Process: Iteration

- **Issue: Peds CT Chest Angio "too noisy" at site X**
- **Dose too low**
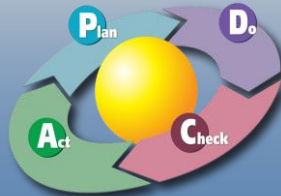 - **Confirmed by literature search and site comparison**
- **Plan: Bump mA on machine**

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Optimization Process: Iteration

- **Do: Compare scanned phantom with and without bump then scan a new patient**
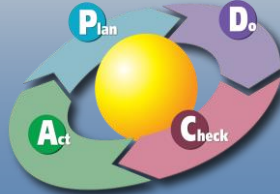 - **Might just jump to patient**

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Optimization Process: Iteration

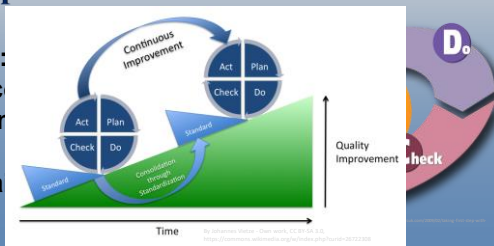- **Check: Ask Peds section chief if new image quality is acceptable**

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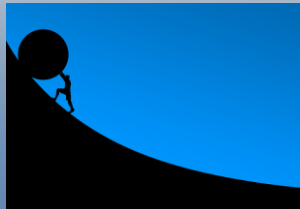## Optimization Process: Iteration

- **Act: becc stan the aga**

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Time vs Effort vs Outcome

- **What do you have FTE to do?**
- **Impression is ok**
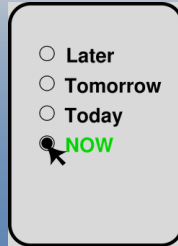- **Quantitative Deep dive is better**
- **Proactive to head off issues**

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Prioritize

- **Most Performed**
- **Complaints**
- **Pediatric**
- **Specialty Scans**
- **Highest Dose**

○ **Later**
○ **Tomorrow**
○ **Today**
● **NOW**

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What Do the Regulations Say?

- **ACR and JC regs don't really call out matching standardization**
  - **Reviewed**
  - **Based on Standards**

Standard PC.01.03.01
The organization plans the patient's care.

Elements of Performance for PC.01.03.01
A 25. The organization establishes or adopts diagnostic computed tomography (CT) imaging protocols based on current standards of practice, which address key criteria including clinical indication, contrast administration, age (to indicate whether the patient is pediatric or an adult), patient size and body habitus, and the expected radiation dose index range. . . .

Note: *This element of performance does not apply to dental cone beam CT radiographic imaging studies performed for diagnosis of conditions affecting the maxillofacial region or to obtain guidance for the treatment of such conditions.*

A 26. Diagnostic computed tomography (CT) imaging protocols are reviewed and kept current with input from an interpreting radiologist, medical physicist, and lead imaging technologist to make certain that they adhere to current standards of practice and account for changes in CT imaging equipment. These reviews are conducted at time frames identified by the organization. . . .

Note: *This element of performance does not apply to dental cone beam CT radiographic imaging studies performed for diagnosis of conditions affecting the maxillofacial region or to obtain guidance for the treatment of such conditions.*

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Beyond fiddling with numbers

- **Could keep scanners from doing certain scans, business decision**
  - **Used those old scanners and protocols for a long time – was that malpractice**
- **Admins important**

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Should They Match?

- **Do you limit new to match old?**
  - **Probably not**
- **Do you reroute around old machines**
  - **Maybe**

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Cite This Talk/Handout

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Thank You!