Real World Experience: Developing Dose and Protocol Monitoring from Scratch

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Outline

- CT protocol monitoring
  - Let’s build a protocol book!
- CT dose monitoring

From scratch: status as of ~2015

- Fleet of 8-9 Philips CT scanners, mix of inpatient, outpatient, dedicated pediatric
- Radimetrics installed, about 60% of CT studies recorded

- Events:
  - Major software upgrade on some scanners (Philips iPatient)
  - 3 scanners replaced, which added GE
  - Opening of remote facility

- Personnel transitions (CT manager)
- No dedicated CT physicist

CT Protocol Monitoring and Optimization

- Joint Commission Standard PC.01.03.01: The [critical access] hospital plans the patient's care.

A 25. The [critical access] hospital 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

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 [critical access] hospital.

JC requirements

- CT Quality Policy was established
  - CT Quality Core Team created, tasked with protocol and dose review

CT Protocol Review and Optimization

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To reduce the radiation dose associated with CT scans, much attention is focused on CT protocol review and improvement. In fact, annual protocol reviews will soon be required for ACR CT accreditation. A major challenge in the protocol review process is determining whether a current protocol is optimal and deciding what steps to take to improve it. In this paper, the authors describe methods for pinpointing deficiencies in CT protocols and provide a systematic approach for optimizing them. Emphasis is placed on a team approach, with a team consisting of at least one radiologist, one physicist, and one technologist. This core team completes a critical review of all aspects of a CT protocol and carefully evaluates proposed improvements. Changes to protocols are implemented only with consensus of the core team, with consideration of all aspects of the CT examination, including image quality, radiation dose, patient care and safety, and workflow.

Key Words: CT, protocol, radiation dose

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The protocols

"Routine critical and systematic review of protocols are necessary not only to ensure that appropriate radiation dose levels are being used but also to verify that other aspects of are acceptable and consistent with best practice standards."

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Protocol review: What **are** our protocols?

What are the parameters?

The protocols

"Routine critical and systematic review of protocols are necessary not only to ensure that appropriate radiation dose levels are being used but also to verify that other aspects of are acceptable and consistent with best practice standards."

- Typically > 200 imaging protocols per scanner
- Need the actual CT protocols

The protocols

"Routine critical and systematic review of protocols are necessary not only to ensure that appropriate radiation dose levels are being used but also to verify that other aspects of are acceptable and consistent with best practice standards."

- Typically > 200 protocols per scanner
- Need the actual CT protocols
- Not all vendors/models produce a COMPLETE human readable listing of protocol parameters

Our solution: getting scanner protocols

- Have service engineer retrieve protocol backup files (Philips)
- Philips iPatient software produces a text-file (html format)
- GE Revolution CT series produce csv files
  - incomplete
    - no series labels
    - Revolution CT: No pitch factor, protocol numbering omitted

Using the protocols (i.e., review logistics)

- Text protocol formatting may not be amenable for review
- Radimetrics has a protocol editor
  - May or may not import your protocol parameters
- Our solution:
  - Parse protocols using a scripting language (**python**, matlab, etc)
  - Generate excel master protocol for each scanner

Acquisition parameters

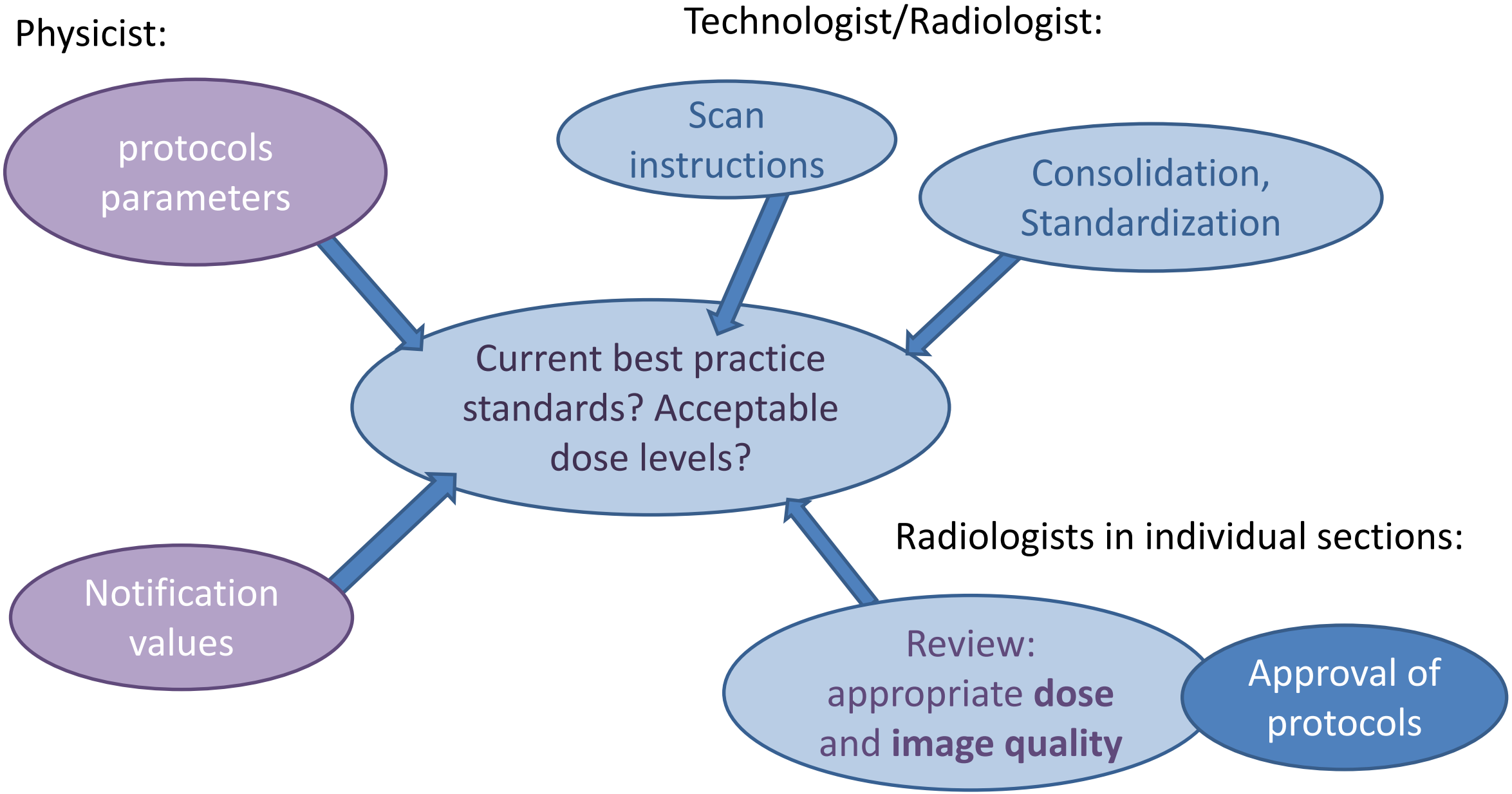
Protocol Name	Anatomy	acqNum	kV	mAs	Patient Size	Pitch	Rotation Time	Collimation	DoseRight Index	Z-Modulation	D Modulation	Absolute Min mAs	Liver Area DoseRight Index	CTDIvol	DLP	Dose Not. Value CTDIvo	Dose Not. Value DLP
ABD/PEL W	Abdomen	1	120	128	90-120kg	0.976	0.5	128x0.625	[illegible]	Yes	Yes	100	3	[illegible]	[illegible]	50	None
ABD/PEL W	Abdomen	2	120	128	90-120kg	0.976	0.5	128x0.625	[illegible]	Yes	Yes	100	3	[illegible]	[illegible]	50	None
ABD/PEL W/O	Abdomen	1	120	128	90-120kg	0.976	0.75	128x0.625	[illegible]	Yes	Yes	100	3	[illegible]	[illegible]	50	None
CHEST/ABD/PEL W	Abdomen	1	120	81	50-90kg	0.976	0.5	128x0.625	[illegible]	Yes	Yes	100	3	[illegible]	[illegible]	50	None
CHEST/ABD/PEL W	Abdomen	2	120	81	50-90kg	0.993	1	128x0.625	[illegible]	Yes	Yes	None	5	[illegible]	[illegible]	50	None
CHEST/ABD/PEL WO	Abdomen	1	120	128	90-120kg	0.976	0.5	128x0.625	[illegible]	Yes	Yes	None	5	[illegible]	[illegible]	50	None
DEDICATED ADRENAL	Abdomen	1	120	128	90-120kg	0.976	0.75	128x0.625	[illegible]	Yes	Yes	100	3	[illegible]	[illegible]	50	None
DEDICATED ADRENAL	Abdomen	2	120	128	90-120kg	0.976	0.75	128x0.625	[illegible]	Yes	Yes	100	3	[illegible]	[illegible]	50	None
DEDICATED ADRENAL	Abdomen	3	120	128	90-120kg	0.976	0.75	128x0.625	[illegible]	Yes	Yes	100	3	[illegible]	[illegible]	50	None
DEDICATED KIDNEY	Abdomen	1	120	128	90-120kg	0.976	0.75	128x0.625	[illegible]	Yes	Yes	100	3	[illegible]	[illegible]	50	None
DEDICATED KIDNEY	Abdomen	2	120	128	90-120kg	0.976	0.75	128x0.625	[illegible]	Yes	Yes	100	3	[illegible]	[illegible]	50	None
DEDICATED KIDNEY	Abdomen	3	120	128	90-120kg	0.976	0.75	128x0.625	[illegible]	Yes	Yes	100	3	[illegible]	[illegible]	50	None
DEDICATED LIVER	Abdomen	1	120	161	90-120kg	0.976	0.75	128x0.625	[illegible]	Yes	Yes	100	0	[illegible]	[illegible]	50	None
DEDICATED LIVER	Abdomen	2	120	161	90-120kg	0.976	0.75	128x0.625	[illegible]	Yes	Yes	100	0	[illegible]	[illegible]	50	None
DEDICATED LIVER	Abdomen	3	120	161	90-120kg	0.976	0.75	128x0.625	[illegible]	Yes	Yes	100	0	[illegible]	[illegible]	50	None
DEDICATED LIVER	Abdomen	4	120	161	90-120kg	0.976	0.75	128x0.625	[illegible]	Yes	Yes	100	0	[illegible]	[illegible]	50	None
DEDICATED PANCREAS	Abdomen	1	120	128	90-120kg	0.976	0.75	128x0.625	[illegible]	Yes	Yes	100	3	[illegible]	[illegible]	50	None
DEDICATED PANCREAS	Abdomen	2	120	128	90-120kg	0.976	0.75	128x0.625	[illegible]	Yes	Yes	100	3	[illegible]	[illegible]	50	None
DEDICATED PANCREAS	Abdomen	3	120	128	90-120kg	0.976	0.75	128x0.625	[illegible]	Yes	Yes	100	3	[illegible]	[illegible]	50	None
DEDICATED PANCREAS	Abdomen	4	120	128	90-120kg	0.976	0.75	128x0.625	[illegible]	Yes	Yes	100	0	[illegible]	[illegible]	50	None

Reconstruction parameters

Protocol Name	Anatomy	acqNum	reconLabel	Orientation	Thickness	Increment	Enhancement	Filter	iDose Level	Field Of View	Window Width	Window Center
CHEST W	Thorax	1										
CHEST W	Thorax	1-recon	2.1 AXL	Axial	3	3	0	Standard (B)	2	449	400	40
CHEST W	Thorax	1-recon	2.2 COR	Coronal	4	4	0	Standard (B)	2	448	400	40
CHEST W	Thorax	1-recon	2.3 SAG	Sagittal	4	4	0	Standard (B)	2	448	400	40
CHEST W	Thorax	1-recon	2.4 MIP	Axial	10	5	0	Standard (B)	2	445	2000	-450
CHEST W	Thorax	1-recon	2.5 MinIP	Coronal	7.2	7.2	0	Standard (B)	2	436	1200	-450
CHEST W	Thorax	1-recon	2.6 LUNGS	Axial	3	3	0.5	Detail (D)	2	449	2000	-450
CHEST W	Thorax	1-recon	2.7 HI RES	Axial	1	1	0.5	Detail (D)	2	449	2000	-450
CHEST W	Thorax	1-recon	2.8 AXL SOURCE	Axial	0.9	0.9	0	Standard (B)	2	350	400	40
CHEST WO	Thorax	1										
CHEST WO	Thorax	1-recon	2.1 AXL	Axial	3	3	0	Standard (B)	2	449	400	40
CHEST WO	Thorax	1-recon	2.2 COR	Coronal	4	4	0	Standard (B)	2	448	400	40
CHEST WO	Thorax	1-recon	2.3 SAG	Sagittal	4	4	0	Standard (B)	2	448	400	40
CHEST WO	Thorax	1-recon	2.4 MIP	Axial	10	5	0	Standard (B)	2	445	2000	-450
CHEST WO	Thorax	1-recon	2.5 MinIP	Coronal	7.2	7.2	0	Standard (B)	2	436	1200	-450
CHEST WO	Thorax	1-recon	2.6 LUNGS	Axial	3	3	0.5	Detail (D)	2	449	2000	-450
CHEST WO	Thorax	1-recon	2.7 HI RES	Axial	1	1	0.5	Detail (D)	2	449	2000	-450
CHEST WO	Thorax	1-recon	2.8 AXL SOURCE	Axial	0.9	0.9	0	Standard (B)	2	350	400	40

Multiple vendors: Consistency of protocols

- Perfect parameter match not always possible
  - GE: 3.75mm slice interval
  - Philips: 4mm slice interval


Physicist:
Technologist/Radiologist:
protocols parameters
Scan instructions
Consolidation, Standardization
Current best practice standards? Acceptable dose levels?
Notification values
Radiologists in individual sections:
Review: appropriate **dose** and **image quality**
Approval of protocols


TEAM

The team

"Protocol review and improvement efforts should be undertaken by a core team consisting of at least one radiologist, one physicist, and one technologist."

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- Radiologist can only oversee protocols relevant to their section
  - Generally cannot approve CT protocols for a different section (i.e., thoracic radiologist cannot approve neuro protocols)

The team

"Protocol review and improvement efforts should be undertaken by a core team consisting of at least one radiologist, one physicist, and one technologist."

- CT clinical manager(s) oversees CT

The team

"Protocol review and improvement efforts should be undertaken by a core team consisting of at least one radiologist, one physicist, and one technologist."

- CT clinical manager(s) oversees CT
  - Can get access to scanners (master of the schedule)
  - Knows the protocols
  - Controls how CT scanners are set up (i.e., password protection of protocol editor)

.. DO password protect your CT protocols - all changes are made in the best intent ..

Must-haves:

- Support from the administration:
  - Dedicated, protected technologists' time ($$)
- CT manager support critical
  - Appoints one dedicated technologist ("technical coordinator")
  - Scheduling: protected time **OFF THE FLOOR** to help with protocols
    - Difficult if there are staffing shortages
  - Controls CT schedule (block scanner time for protocol updates, notification settings)
- Lead technologist may not be ideal, as they already have many other responsibilities

Let's Build Something Together!

A protocol book

- Protocol book:
  - Scan instructions: Technologist/radiologist
  - Scan parameters: Physicist

- Protocol book helps establish standard
  - Technologists' will change scan parameters on the fly because *A* radiologist requested scan *A* to be done in a certain way ..

ADULT HEAD

3-10-2017

CT Protocol

Philips iCT

HELICAL BRAIN

Icon

Indications:

Headache, CVA, Trauma

Oral Contrast:

Contrast:	Omnipaque 350 100mL
IV:	22-20 gauge optimal
Rate:	2.0cc sec
Delay:	Immediate
Saline:	Optional

Scan Guidelines:

1. Patient supine and centered to the area of interest
2. Tilt Patient chin downward towards the chest with the scan plane parallel to the OML & Skull base

Presentation State:

Paperwork, Scout, Axial ST, Axial Bone, Sag ST, Cor ST, Cor Bone, Cor ST

Dose Alert:

CTDIvol = 1000mGy

Scan overview:

1. Scout
2. Helical Scan

Order:

HEAD WO
HEAD W/WO
HEAD W

SURVIEW

Angle: Lateral, **Technique:**120 kV, 30 mA

SERIES 1

Scan parameters

kV	120
mAs	350
Resolution	High
Pitch	0.39
Rot. time	0.4
Auto Time	No
Collimation	64x0.625
DRI	0
Z Modulation	No
Brain DRI	0
min mAs	None
max mAs	None
CTDIvol	47.6
DLP	928.1
Scan Length	160
CTDIvol NV	80

Reconstruction parameters

Name	AXL ST	COR ST	SAG ST	AXL BONE	COR BONE	SAG BONE	THIN ST	THIN BONE
Orientation	Axial	Coronal	Sagittal	Axial	Coronal	Sagittal	Axial	Axial
Thickness	5	2.5	3	5	3	3	0.9	0.9
Increment	5	2.5	3	5	3	3	0.45	0.45
Filter	Brain Sharp (UC)	Brain Sharp (UC)	Brain Sharp (UC)	Y-Detail (YD)	Y-Detail (YD)	Y-Detail (YD)	Brain Sharp (UC)	Y-Detail (YD)
Enhancement	0	0	0	0	0	0	0	0
iDose Level	2	2	2	2	2	2	2	2
FOV	249	247	249	249	249	249	249	249
Window Center	40	40	40	600	600	600	40	600
Window Width	80	80	80	2400	2400	2400	80	2400

Our approach to building a protocol book

- Goal: Build a protocol book that is flexible, editable, allowing for automated updating of scan parameters

- Requirements:
  - Easy exchange with technologists/clinicians (MS office)
  - Automated scan parameter update

- To disseminate:
  - Utilize MS sharepoint
    - Use .aspx extension to display html

Software tool	Data entry: clinical instructions	Data entry: scan parameters	Data entry: Scan parameter update	Clarity of layout	Access/ Publishing	Version control
MS Word	Good	Manual or linked fields	Manual Linked	User defined	Upload individually, open in Word	Needs to be maintained by user
MS Excel	Can be cumbersome (cell layout)	Manual or linked cells	Manual Linked	User defined	Upload individually, open in Excel	Needs to be maintained by user
HTML	Need special editor, or direct html	Via scripting	Via scripting,	User defined	Via scripting, displays as website (sharepoint)	Needs to be maintained by user
Radimetrics protocol editor	Good	Automated (depends on CT manfr) / Manual	Manual	Not user adjustable, poor layout	Export to pdf and upload individually	Tracks protocol version

CT Protocol Monitoring and Optimization

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  A 25. The [critical access] hospital **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**.

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CT dose monitoring

- Order? Protocol? Study Description? Exam card?

- Terminology is not defined. Be careful when communicating.

Understand your workflow

Referring physician orders study

CT CHEST W

in structured dose report
“order”, ”study description”

Radiology resident reviews order and clinical history, selects scan protocol

- Standard contrast-enhanced chest
- Interstitial lung disease
- …

visible on ERM only
“protocolling”

Technologist chooses size-specific protocol, or may adjust technique for patient size

- Standard Chest
- Interstitial lung disease
- …

”protocol”, “exam card”
retrieved from images

-> requires images to be sent to monitoring software

Dose reporting

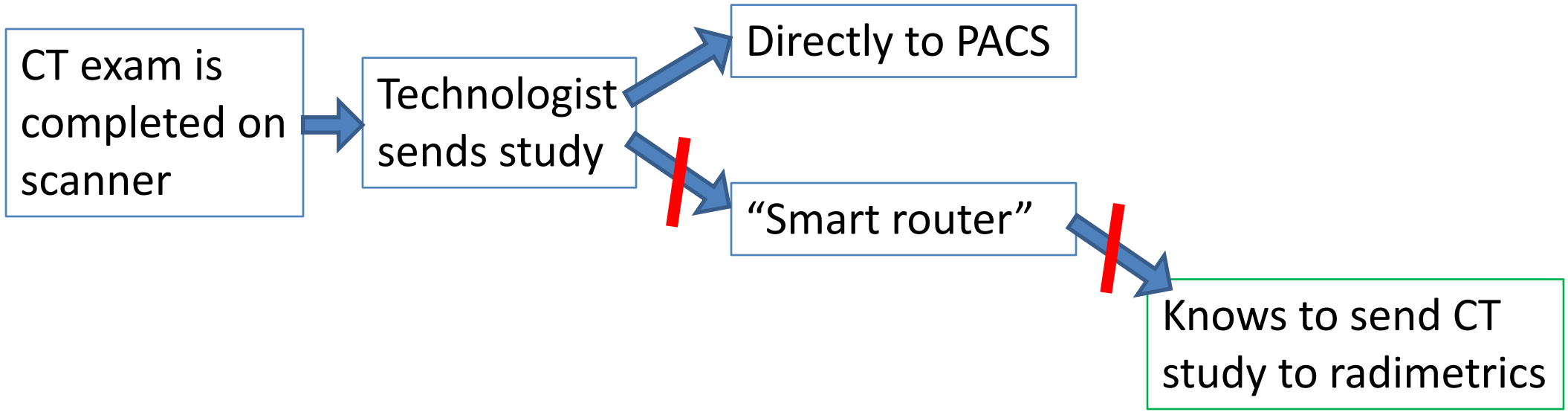
- By study description/order
  - Imaging protocol not known
  - Not as useful for scan parameter optimization
- By scan protocol
  - Same imaging protocol may be used for different orders
- DIR: by order

CT dose monitoring

Where have all the studies gone ..

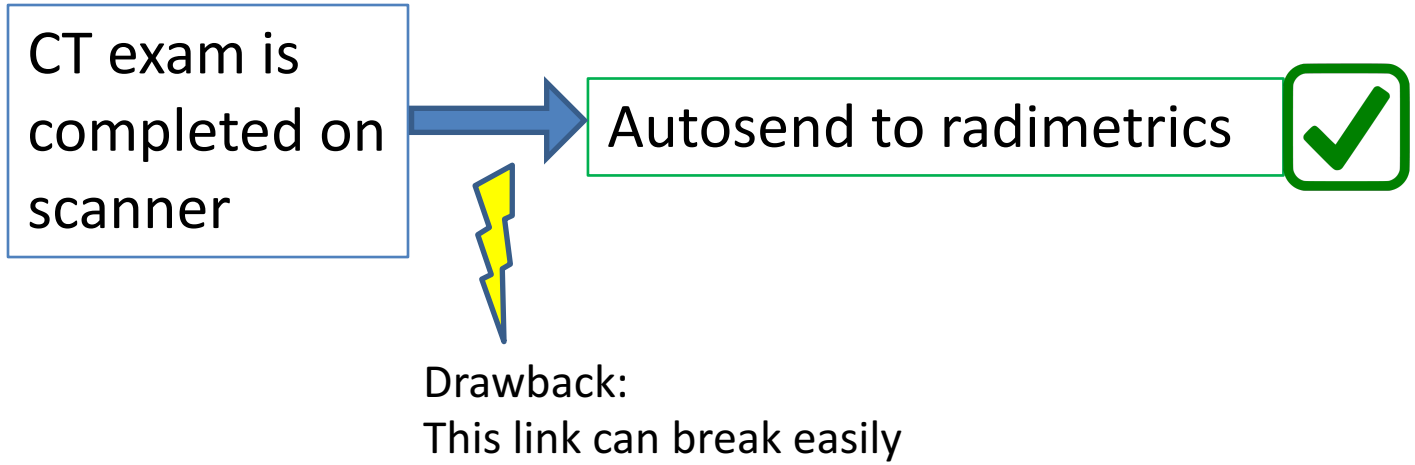
Understand your IT: What gets send where?

Initial setup:



IT needs to be part of the equation

New setup:



Final words

- Establishing protocol/dose monitoring is not trivial
- Administration support (dedicated technologists' time costs $$)
- Know your systems, your workflow

- Build a DEDICATED team
  - Need to be on the same page with technologists/radiologists
  - Get someone from IT who CAN HELP
- Know your medical physics colleagues, reach out to someone with similar environment

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