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Starting small: Implementing a CT protocol optimization program

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ABSTRACT

This talk describes our organization's CT optimization program, and how we have adapted it to make efficient use of limited physicist time.

Methods
Our healthcare organization includes over 30 sites with CT scanners in multiple models, and several radiologist groups. We started optimizing and documenting protocol settings across models 3 years ago, with about 1/3 FTE physicist time available for this project.

For effective use of physicist time, documentation responsibilities are divided between physicist and CT supervisors, with the physicist focusing on scan settings and reconstruction settings. The optimization process involves the physicist, the CT supervisor and one radiologist for each exam category (Neuro, Abdominal, Thoracic etc.) The radiologists provide requirements on reconstruction details, feedback on image quality and decisions on dose vs image noise tradeoffs. We have been working through protocols in an order based on exam frequency and clinical feedback.

Results
Our efforts began with common protocols such as routine Abdo/Pelvis, Head and Chest. The process yielded immediate results, as many protocols had potential improvements to make on at least some models. We have now improved and documented the majority of our protocols on most of our scanner models. The most common adjustments are dose settings, scan speeds, reconstruction kernel and IR settings, and slice thickness. This is an ongoing process, and the current protocols will be revisited regularly during protocol reviews.

Conclusion
Our protocol optimization program can be scaled to more sites as needed, and we plan to expand to more of our radiologist groups in the near future.

INTRODUCTION

Avera is a regional health system with several dozen sites across four states, ranging from large and small hospitals to outpatient centers. In 2023, when sufficient physicist time became available, we increased the scope of our CT protocol documentation and optimization program. While we already had several aspects of our protocols documented, we wanted to add specifics to cover the parameter differences between specific scanner models, and also to review and improve parameters on all models. This poster describes what we have implemented so far.

Scope of our CT protocol program
We have over 30 sites with CT, and over 40 scanners in multiple models from 3 vendors. We have five radiologist groups covering different geographic areas, and our program needs to allow for some different preferences between groups on image reconstruction settings.

Goals for our program
- Ensure consistent image quality across sites with different models (i.e. noise level, kernels, recons done)
- Monitor delivered doses (patient $CTDI_{vol}$ distributions) and reduce dose settings that are higher than needed
- Address radiologist feedback & requests on image quality
- Provide documentation for staff programming or updating protocols on scanners, for each model
- Cover sites and most common protocols while optimizing the use of limited physicist time (about 0.3 FTE available)

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The roles of the staff involved in the program are:

Radiologists
We started by working with a single radiologist group (our largest). For each exam category (i.e. Abdominal, Thoracic, Neuro etc.), one radiologist was designated as the protocol contact. The contact radiologist's tasks include:
- Providing feedback on image quality when requested
- Specifying details on the reconstructions required: slice thicknesses, MIPs and MPRs etc.
- Making the final decisions on tradeoffs between dose settings and image noise levels

In addition, all radiologists can provide continuous image quality feedback on individual exams, using the built in QA reporting feature on our PACS system.

CT Technologists
At each site we have one or more technologists who are responsible for updating protocols on the scanners and corresponding with the physicist on protocol settings.
Protocol documents for the whole program are distributed to sites using Microsoft Teams. One person, in our case the CT manager at our largest hospital, maintains the Teams site and also maintains one of our two types of protocol documents (see details on our document types below).

Medical Physicist
The physicist's most time-intensive task is the ongoing review of scanner parameters for different protocols. For each reviewed protocol this involves:
- Evaluating patient dose distributions using monitoring software (we use DoseMonitor by PACSHealth)
- Collecting the physics-relevant scan and reconstruction parameters from each scanner, using data from DoseMonitor, clinical images, and/or the CT consoles
- Getting feedback from the contact radiologist on image quality trends across sites and scanners
- Using the above information to identify any outliers in the scan or reconstruction settings which may benefit from adjustments. Then deciding on any changes, in consultation with the radiologist and site technologist.
- Communicating parameter changes to sites

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Medical Physicist (continued)
Other physicist tasks in the program include:
- Updating and maintaining our second type of protocol documents (see below)
- Monthly, reviewing PACS QA reports from radiologists to see if any are related to protocol settings and investigating if needed
- Taking requests from sites and radiologists for modifications to protocol settings, or for new protocols
- Verifying the functionality of AEC parameters, using phantoms

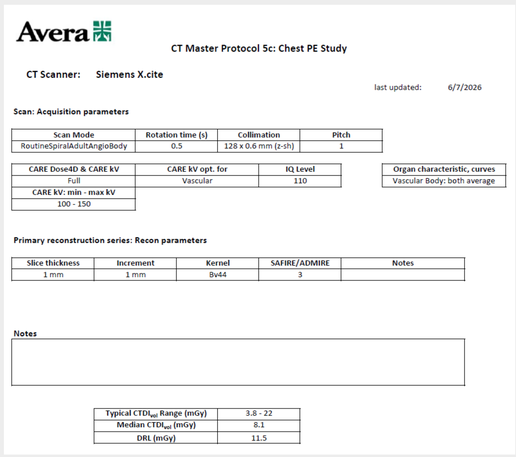
Documentation of protocols
To make effective use of limited physicist time, we have two document types for each protocol: only one of these, with model-specific parameter settings, is maintained by the physicist. The physicist only focuses on scan and reconstruction parameters which depend on the scanner model. Other protocol information is maintained by the CT manager. Tables 1 and 2 show how we divide each protocol's information into these two documents.

Table 1. Our division of information into two types of documents.

Document 1: General protocol information	Document 2: Model-specific parameters
Maintained by CT Manager	Maintained by Physicist
All information that is not in document 2	Only physics-related and model-specific information
One document for each exam type (e.g. Abdo/Pel W, Abdo/Pel WO, Urogram)	One document for each scan type (e.g. a routine Abdo/Pelvis scan)
Referred to by Technologists whenever required	Usually referred to only when updating protocols on a scanner

Table 2. Examples of specific items in each document

Document 1: General protocol information	Document 2: Model-specific parameters
Indication	Collimation, rotation time, pitch
Contrast and timing	All AEC parameters, kV and mA information etc.
Positioning, scan range, direction etc.	Any other vendor-dependent parameters
List of all recon series, thickness and spacing	Kernel and IR settings for reconstructions
Any other required information	Statistics on expected CTDIvol distribution


Avera

CT Master Protocol 5c: Chest PE Study

CT Scanner: Siemens X.cite

last updated: 6/7/2026

Scan: Acquisition parameters

Scan Mode	Rotation time (s)	Collimation	Pitch
RoutineSpiralAdultAngioBody	0.5	128 x 0.6 mm (z-sh)	1

CARE Dose4D & CARE kV	CARE kV opt. for	IQ Level	Organ characteristic, curves
Full	Vascular	110	Vascular Body: both average
CARE kV: min - max kV			
100 - 150			

Primary reconstruction series: Recon parameters

Slice thickness	Increment	Kernel	SAFIRE/ADMIRE	Notes
1 mm	1 mm	Bv44	3	

Notes

Typical $CTDI_{vol}$ Range (mGy)	3.8 - 22
Median $CTDI_{vol}$ (mGy)	8.1
DRL (mGy)	11.5

Figure 1. Example from a parameters document (maintained by the Physicist). This is the entry for one model type, from one protocol document. Note the simplicity: only the main parameters are included. Any MIPs and MPRs are covered in the other (general, type 1) document.

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Since a given type of scan can appear in multiple types of exams, multiple type 1 documents may refer to a single type 2 document (following the concept described in Ref. [1]).

Protocol reviews
Our two types of protocol documents can be reviewed and updated on separate schedules.
- Our time limit between reviews for each general protocol document is three years, although they are frequently updated more often. This process only needs to involve the contact radiologist and CT manager.
- For the parameters documents we also have a three year limit. These are updated by the physicist as part of the parameter review process; again, some are updated more frequently, whenever a protocol needs to be worked on. If the document contains a model for which we have an ACR accredited scanner, that scanner's settings are checked on a 2 year interval.

RESULTS

We started implementing the new optimization and documentation process with the most common exams, such as routine head, abdomen/pelvis and chest. Progress in optimizing parameters has been determined mainly by the availability of physicist time. At present we have gone through at least one iteration on almost all of our protocols, excluding some of the less common and more specialized ones. We now have about 40 parameters documents in use.

For most protocols, it has been common for several scanners to have some parameters adjusted. Most scan adjustments have been simple changes in dose settings, pitch, rotation time and kV range (in cases with auto-kV setting). Most reconstruction adjustments have been to slice thickness, kernel or IR settings. In the first iteration with each protocol, we have focused on dealing with dose outliers and image quality feedback from radiologists, rather than spending extra time to make settings across models correspond as exactly as possible.

Our next steps will be:
- Finishing the first optimization iterations on protocols we have not addressed yet
- Continuing regular reviews on all protocols, for both categories of documents, within our established time frames
- Expanding the optimization process to the other radiologist groups in our system (details of this will be determined by how the groups decide to organize it)

CONCLUSIONS

Our experience has shown that, with an efficient use of physicist time, CT protocol optimization can rapidly yield useful results without spending large amounts of time and organizational resources. A program can start out addressing protocols one at a time, prioritized by radiologist feedback and/or exam frequency. By sharing tasks between physicist, technologists and radiologists, steady progress can be made with a fraction of a physicist FTE.

ACKNOWLEDGEMENTS

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REFERENCES

1. Szczykutowicz, Timothy P., Robert K. Bour, Nicholas Rubert, Gary Wendt, Myron Pozniak, and Frank N. Ranallo. "CT protocol management: simplifying the process by using a master protocol concept." *Journal of applied clinical medical physics* 16, no. 4 (2015): 228-243.