An Automated CT Protocol Reformatting Program for Protocol Documentation and Review

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Purpose

- The American College of Radiology (ACR) and the Joint Commission (TJC) require the ongoing review and management of computed tomography (CT) protocols by a team of radiologists, physicists, and technologists.
- Manually reviewing a single protocol across multiple scanners is a laborious task and is aggravated by the large amount of protocols on each CT scanner.
- For institutions with multiple CT scanners from different vendors, acquiring protocols and comparing parameters is complicated by vendor-specific naming conventions, variable protocol templates, and immutable documents.
- The purpose of this study was to develop a software solution that automatically reformats the protocol files exported from CT scanner consoles into a consolidated, vendor-independent format to facilitate and expedite the protocol review process.

Part 1: Methods

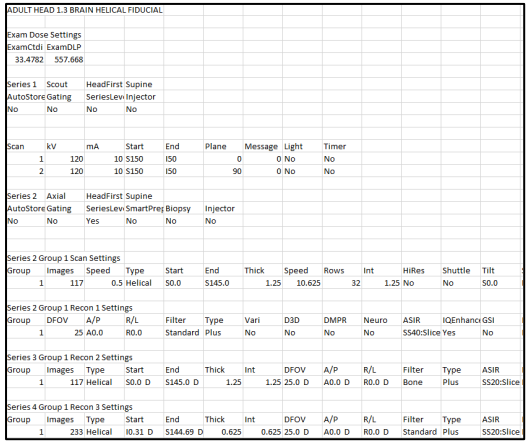
We proposed taking advantage of the exported protocol files (in either CSV or XML formats) to create a digital protocol book that is updated regularly.

1. A Python script-based program was created to identify and store values for the following parameters:

- tube potential (kV)
- tube current (mA)
- automatic exposure control reference
- pitch
- minimum and maximum tube current (if applicable)
- tube rotation time (sec)
- collimation
- computed tomography dose index (CTDI)
- CTDI notification value (if applicable)
- dose-length product (DLP)
- slice thickness
- slice interval
- displayed field of view (DFOV)
- reconstruction kernel
- iterative reconstruction algorithm setting

Part 1: Methods

2. The program was created for and tested on protocol export files from multiple Siemens, GE, Canon (formerly Toshiba), and Philips scanners.
   - Each value was extracted from the exported protocol files, and calculations were automatically performed when needed to account for differences in reported parameters between vendors (e.g. Philips reports mAs, while GE reports mA).



ADULT HEAD 1.3 BRAIN HELICAL FIDUCIAL

Exam Dose Settings

ExamCtdi	ExamDLP
33.4782	557.668

Series 1	Scout	HeadFirst	Supine
AutoStore	Gating	SeriesLev	Injector
No	No	No	No

Scan	kV	mA	Start	End	Plane	Message	Light	Timer
1	120	10	S150	I50	0	0	No	No
2	120	10	S150	I50	90	0	No	No

Series 2	Axial	HeadFirst	Supine
AutoStore	Gating	SeriesLev	SmartPreg
No	No	Yes	No

Biopsy	Injector
No	No

Series 2 Group 1 Scan Settings

Group	Images	Speed	Type	Start	End	Thick	Speed	Rows	Int	HiRes	Shuttle	Tilt
1	117	0.5	Helical	S0.0	S145.0	1.25	10.625	32	1.25	No	No	S0.0

Series 2 Group 1 Recon 1 Settings

Group	DFOV	A/P	R/L	Filter	Type	Vari	D3D	DMPR	Neuro	ASIR	IQEnhanc	GSI
1	25	A0.0	R0.0	Standard	Plus	No	No	No	No	S540:Slice	Yes	No

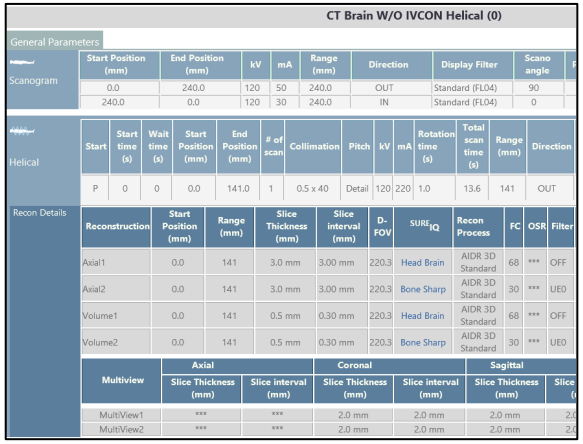
Series 3 Group 1 Recon 2 Settings

Group	Images	Type	Start	End	Thick	Int	DFOV	A/P	R/L	Filter	Type	ASIR
1	117	Helical	S0.0 D	S145.0 D	1.25	1.25	25.0 D	A0.0 D	R0.0 D	Bone	Plus	S520:Slice

Series 4 Group 1 Recon 3 Settings

Group	Images	Type	Start	End	Thick	Int	DFOV	A/P	R/L	Filter	Type	ASIR
1	233	Helical	I0.31 D	S144.69 D	0.625	0.625	25.0 D	A0.0 D	R0.0 D	Standard	Plus	S520:Slice

(A)



CT Brain W/O IVCON Helical (0)

General Parameters

Scanogram

Start Position (mm)	End Position (mm)	kV	mA	Range (mm)	Direction	Display Filter	Scano angle
0.0	240.0	120	50	240.0	OUT	Standard (FL04)	90
240.0	0.0	120	30	240.0	IN	Standard (FL04)	0

Helical

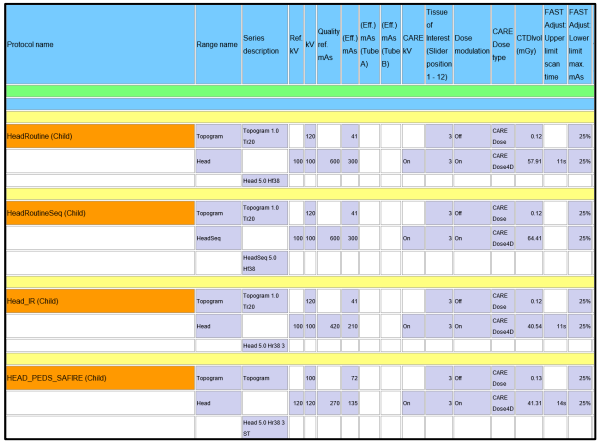
Start	Start time (s)	Wait time (s)	Start Position (mm)	End Position (mm)	# of scan	Collimation	Pitch	kV	mA	Rotation time (s)	Total scan time (s)	Range (mm)	Direction
P	0	0	0.0	141.0	1	0.5 x 40	Detail	120	220	1.0	13.6	141	OUT

Recon Details

Reconstruction	Start Position (mm)	Range (mm)	Slice Thickness (mm)	Slice interval (mm)	D-FOV	SURE IQ	Recon Process	FC	OSR	Filter
Axial1	0.0	141	3.0 mm	3.00 mm	220.3	Head Brain	AIDR 3D Standard	68	***	OFF
Axial2	0.0	141	3.0 mm	3.00 mm	220.3	Bone Sharp	AIDR 3D Standard	30	***	UEO
Volume1	0.0	141	0.5 mm	0.30 mm	220.3	Head Brain	AIDR 3D Standard	68	***	OFF
Volume2	0.0	141	0.5 mm	0.30 mm	220.3	Bone Sharp	AIDR 3D Standard	30	***	UEO

Multiview	Axial		Coronal		Sagittal	
	Slice Thickness (mm)	Slice interval (mm)	Slice Thickness (mm)	Slice interval (mm)	Slice Thickness (mm)	Slice
MultiView1	***	***	2.0 mm	2.0 mm	2.0 mm	2.0
MultiView2	***	***	2.0 mm	2.0 mm	2.0 mm	2.0

(B)



Protocol name	Range name	Series description	Ref kV	kV	Quality ref mAs	(Eff.) mAs	(Eff.) mAs (Tube A)	(Eff.) mAs (Tube B)	CARE kV	Tissue of Interest (Slider position 1 - 12)	Dose modulation	CARE Dose type	CTDIvol (mGy)	FAST Adjust Upper limit scan time	FAST Adjust Lower limit max mAs
HeadRoutine (Child)	Topogram	Topogram 1.0 Tr20		120		41				3	Off	CARE Dose	0.12		25%
	Head			100	100	600	300		On	3	On	CARE Dose4D	57.91	11s	25%
		Head 5.0 Hr38													
HeadRoutineSeq (Child)	Topogram	Topogram 1.0 Tr20		120		41				3	Off	CARE Dose	0.12		25%
	HeadSeq			100	100	600	300		On	3	On	CARE Dose4D	64.41		25%
		HeadSeq 5.0 Hr38													
Head_IR (Child)	Topogram	Topogram 1.0 Tr20		120		41				3	Off	CARE Dose	0.12		25%
	Head			100	100	420	210		On	3	On	CARE Dose4D	40.54	11s	25%
		Head 5.0 Hr38 3													
HEAD_PEDS_SAFIRE (Child)	Topogram	Topogram		100		72				3	Off	CARE Dose	0.13		25%
	Head			120	120	270	135		On	3	On	CARE Dose4D	41.31	14s	25%
		Head 5.0 Hr38 3 ST													

(C)

Figure 1: (A) The protocol export CSV file from GE scanners (B) The protocol export XML file from Canon scanners (C) The protocol export XML file from Siemens scanners

Part 1: Final Format

Scan/Recon Type	kV	mA	AEC IQ Ref	MinmA	MaxmA	Rot (s)	Coll	Pitch	SFOV	CTDI	CTDI NV	DLP	Thick	Int	DFOV	Kernel	IR	IQEnhance	HiRes	GSI
ADULT PELVIS 8.7 PELVIS W/O IVC ROUTINE																				
Scout 90	120	10																		
Scout 0	120	10																		
Helical Scan/Full Recon	120		11.57	100	440	0.8	16 x 1.250 mm	1.375	Large	8.5248	45	121.898	5	5	36	Standard	None	No	No	
Full Recon													1.25	1.25	36.0 D	Standard	None			No
ADULT PELVIS 8.8 PELVIS W/ IVC ROUTINE																				
Scout 90	120	10																		
Scout 0	120	10																		
Helical Scan/Full Recon	120		11.57	100	440	0.8	16 x 0.625 mm	1.375	Large	13.5203	45	433.052	5	5	36	Standard	None	No	No	
Full Recon													0.625	0.625	36.0 D	Standard	None			No
Helical Scan/Full Recon	120		11.57	50	440	0.8	16 x 0.625 mm	1.375	Large	13.5203	45	433.052	5	5	36	Standard	None	No	No	
Full Recon													3.75	1.9	36	Bone	None			No
ADULT PELVIS 8.10 PELVIS with SMART VIEW																				
Scout 90	120	10																		
Scout 0	120	10																		
Helical Scan/Full Recon	120		11.57	100	440	0.8	16 x 1.250 mm	1.375	Large	8.5248	45	121.898	5	5	36	Standard	None	No	No	
Full Recon													1.25	1.25	36.0 D	Standard	None			No
ADULT LOWER EXTREMITY 9.1 LOWER EXTREMITY-KNEE																				
Scout 90	120	10																		
Scout 0	120	10																		
Helical Scan/Full Recon	120	140				1	16 x 0.625 mm	0.5625	Large	22.245	40	106.221	1.25	1.25	20	BonePlus	None	No	No	
ADULT LOWER EXTREMITY 9.2 LOWER EXTREMITY-ANKLE																				
Scout 90	120	10																		
Scout 0	120	10																		
Helical Scan/Full Recon	120	120				1	16 x 0.625 mm	0.5625	Large	19.0671	30	91.0467	1.25	1.25	20	Bone	None	No	No	
ADULT LOWER EXTREMITY 9.3 LOWER EXTREMITY-TIB/FIB																				
Scout 90	120	10																		
Scout 0	120	10																		
Helical Scan/Full Recon	120	140				1	16 x 0.625 mm	0.5625	Large	22.245	40	918.163	1.25	1.25	20	Detail	None	No	No	

Figure 2: The final format

Part 2

3. An additional Python program was written to identify changes between two sets of protocols from the same scanner exported at different points in time.
   - The program highlights any changes in parameters for each protocol, identifies protocols that have been renamed, identifies new protocols, and identifies the deleted protocols.
   - Both programs primarily use the Pandas library for data manipulation and the xlsxwriter library to apply formatting to the resulting Excel worksheets.

Scan/Recon Type	kV	mA	AEC IQ Ref	MinmA	MaxmA	Rot (s)	Coll	Pitch	SFOV	CTDI	CTDI NV	DLP	Thick	Int	DFOV	Kernel	IR	IQEnhance	HiRes
ADULT CHEST 5.11 CHEST ANGIO PE -25HU (Old)																			
Scout 90	120	20																	
Scout 180	120	10																	
Helical SmartPrep/Plus Recon	120		28	100	600	0.5	64 x 0.625 mm	0.984375	LargeBody	9.7267	30	395.213	0.625	0.625	36	Standard	SS30:Slice	No	No
Full Recon													2.5	2	36.0 D	Standard	SS20:Slice		
Full Recon													2.5	2	36.0 D	Lung	SS20:Slice		
Plus Recon													0.625	0.625	36.0 D	Lung	SS40:Slice		
ADULT CHEST 5.11 CHEST ANGIO PE -25HU (New)																			
Scout 90	120	20																	
Scout 180	120	10																	
Helical SmartPrep/Plus Recon	120		30	100	600	0.5	64 x 0.625 mm	0.984375	LargeBody	8.45	30	344.12	0.625	0.625	36	Standard	SS30:Slice	No	No
Full Recon													2.5	2	36.0 D	Standard	SS20:Slice		
Full Recon													2.5	2	36.0 D	Lung	SS20:Slice		
Plus Recon													0.625	0.625	36.0 D	Lung	SS40:Slice		

Figure 3: The protocol comparison program highlights the protocol changes.

Results

- The consistent, vendor-neutral format accelerates the identification of relevant protocol parameters, speeding up protocol documentation and expediting the review process.
- By maintaining an organized set of protocols with information directly from the scanners, we reduce the risk of human entry errors present when manually entering values into a protocol book.
- The additional protocol comparison program automatically identifies changes in protocols between two points in time, allowing the protocol management team to quickly review the changes for accuracy.

Conclusions

The program we developed saves the protocol management team a significant amount of time that would be spent by manually parsing the raw protocol outputs or entering protocol changes. The program also opens new possibilities for more comprehensive analyses of protocols across vendors and throughout time.