AAPM Working Group on Standardization of CT Nomenclature and Protocols

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Workgroup Co-Chair

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Charge

- Develop consensus protocols for frequently performed CT examinations, summarizing the basic requirements of the exam and giving several model-specific examples of scan and reconstruction parameters.

- Develop a set of standardized terms for use on CT scanners

Membership

- AAPM
  - Mike McNitt-Gray, Bob Pizzutiello, Jim Kofler
- ACR
  - Mark Armstrong, Penny Butler
- ASRT
  - Kevin Reynolds
- FDA
  - Thalia Mills

Manufacturers

- GE
  - John Jaeckle
- Hitachi
  - Mark Silverman
- Philips
  - Mark Olszewski

- Siemens
  - Christianne Liedecker
- Toshiba
  - Rich Mather
- MITA
  - Stephen Vastagh

Scanner Protocols

- Peer review process

- Protocol databases for sites to confirm their approach is reasonable

- AAPM Working Group on Standardization of CT Nomenclature and Protocols
  - Protocols to provide "reasonable" benchmarks
  - Terminology Lexicon

  http://www.aapm.org/pubs/CTProtocols/

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CT Scan Protocols

| Statement of Purpose | Scanner Model & Equipment Performance Questions | Restriction of Access | Access Protocols |

Available Protocols

Adult Protocols

- **Brain Perfusion CT** (added 10/7/2010) [**Give Feedback**]

Your feedback regarding the content of this website is welcome. Feedback regarding this website will not be monitored daily. **Users experiencing problems in performing an exam should contact their service provider.**

ADULT BRAIN PERFUSION CT

Indications
Suspected acute infarction;
Assessment of reperfusion after treatment of acute stroke;
Vasculitis;
New neurological symptoms after subarachnoid hemorrhage suggesting vasospasm;
Evaluation of the hemodynamic significance of a carotid stenosis;
Transient ischemic attack;
Evaluation of the cerebral vascular reserve using acetazolamide challenge;
Evaluation of brain perfusion after significant head trauma;
Brain tumor.

Diagnostic Task
- Detect brain ischemia in stroke, transient ischemic attack, vasculitis;
- Distinguish already-infarcted brain from brain at risk of infarction;
- Identify regions of brain made ischemic by vasospasm;
- Detect altered brain perfusion downstream a significant carotid stenosis;
- Assess altered cerebral vascular reserve in patients with ischemic symptoms;
- Assess altered cerebral perfusion after traumatic brain injury;
- Identify early brain tumor recurrence and higher-grade tumor components.

Key Elements
- Time-resolved scans are used to track the flow of iodinated contrast media through the brain;
- Multiple images (20-40) are acquired over the same section of anatomy;
- Patients must be able to remain still during the exam in order to avoid motion misregistration;
- The table may remain stationary during the entire exam, or move back and forth between a few table positions;
- Whole-brain perfusion CT can be accomplished using CT systems with wide detector arrays (8-16 cm); alternatively, scan modes that move the patient back and forth over the desired scan volumes can be used;
- Acquisitions are repeated at predetermined time intervals (e.g. every second to every 2-3 seconds) for a predetermined duration (e.g. 40-90 seconds);
- Relatively thick image widths are used to minimize image noise (5-10 mm is common);
- Image quality is inferior to a routine head CT. That is, images are noisier and thicker.
- Data are used to generate color maps of hemodynamic significance:
    --Blood volume (BV) and flow (BF), mean transit time (MTT), time to peak perfusion (TPP);
- A non-contrast-enhanced head CT and/or a CT angiogram may be combined with a perfusion CT scan.

Dose Management
- 80 kV should be used to increase iodine signal brightness;
- Low dose per single scan (i.e. one tube rotation) is critical, since repeated scanning will result in a relatively high cumulative dose;
- Time interval between scans, and hence the total number of scans over the exam duration, should be set carefully, taking into account the analysis algorithm (some approaches require relatively dense data points);
- Dose (tube current) modulation should not be used, as it may interfere with the calculation of the BV and BF parameters;
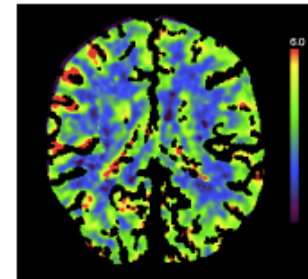
Additional Resources
- ACR Practice Guideline for the Performance of Computed Tomography (CT) Perfusion in Neuroradiologic Imaging. (www.acr.org/SecondaryMainMenuCategories/quality_safety/guidelines/dx/head-neck/ct_perfusion.aspx);
- AJNR Special Collection. Radiation Dose in Neuroradiology CT Protocols. Collection Editors: Max Wintermark and Michael H. Lev (available at www.ajnr.org/specCol/specCollPCTToc.dtl).
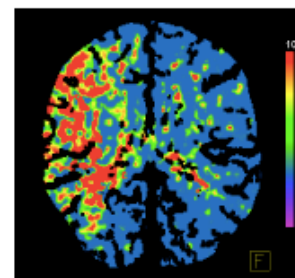
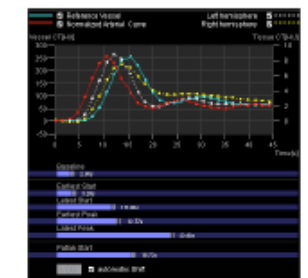**BRAIN PERFUSION CT: Sample Images**
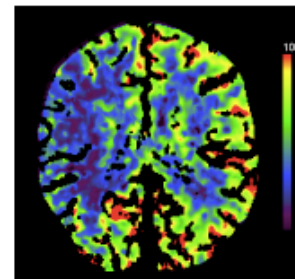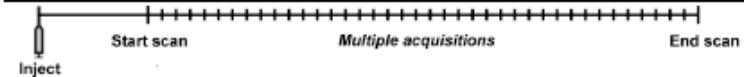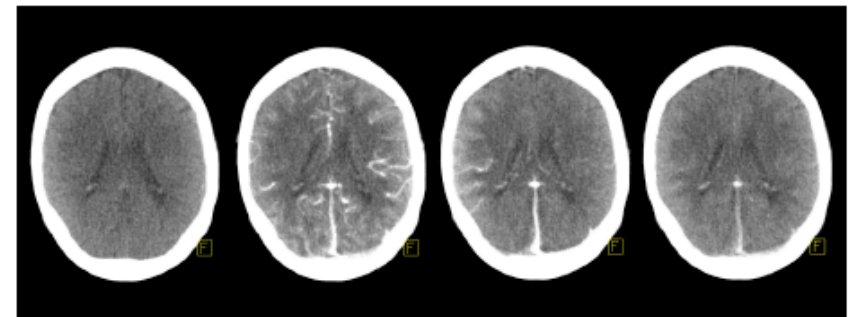
Cerebral Blood Flow (CBF, in mL/100 g/min)   Cerebral Blood Volume (CBV, in mL/100 g)

Mean Transit Time (MTT, in seconds)   Peak Enhancement Curves

BRAIN PERFUSION CT (Selected SIEMENS Scanners)

GENERAL: This protocol may include an optional, non-contrast-enhanced head scan and/or an optional head CT angiogram
Center the table height, such that the external auditory meatus is located at the center of the gantry.
The patient's chin should be tilted toward the chest (i.e. in a "tucked" position).

CONTRAST: **Oral:** None.
IV: 40 mL of 350 mg/cc concentration contrast media at 4 mL/sec followed by 30 mL saline at 4 mL/sec
Preferred injection site: 18–20 gauge IV placed in right antecubital vein

TOPOGRAM: PA and Lateral, 512 mm coverage, 120 kV, 1
(CT Radiograph)

BRAIN PERFUSION CT:
This scan is performed for a continuous 40 o
The radiologist will determine the scan range
No Gantry Tilt for the periodic spiral (ada

SIEMENS	Sensation 64	
Scan Type	Multiscan (Cine)	
Rotation Time (s)	1.0	
Table Motion	None	
Collimation	24 x 1.2 mm	
Coverage per Rotation (mm)	28.8	
Scan Range (mm)	28.8	
Cycle Time	1.0 (continuous)	
Pitch	---	
Feed (mm/rot)	---	
kVp	80	
Effective mAs	270	
CARE Dose 4D	OFF	
Scan Field (mm)	200	
Prep Delay (s)	5	
Scan time (s)	40	
CTDI-vol (mGy)	433	
Base Protocol	NeuroPCT	

RECONSTRUCTION	
Kernel	
Slice (mm)	
Increment (mm)	
FOV	
Window width/window center	

Perfusion computations are performed on an image-processing

BRAIN PERFUSION CT (Selected GE Scanners)

GENERAL: This protocol may include an optional, non-contrast-enhanced head scan and/or an optional head CT angiogram.
Center the table height, such that the external auditory meatus is located at the center of the gantry and the landmarked
at the level of the canthomeatal line (S0). The patient's chin should be tilted toward the chest (i.e. in a "tucked"
position) to minimize the amount of tilt needed to better avoid the eyes especially for modes that do not support tilt.
Perfusion protocols are for adults; modifications must be done for pediatrics.

CONTRAST: **Oral:** None.
IV: 40 ml of 350 -370 mg/cc concentration contrast media at 4 ml
Preferred injection site: 18–20 gauge IV in right antecubital vein
Optional second level can be examined after a 5 to 10 min delay.

SCOUT: PA and Lateral, 200 mm coverage, 120 kV, 10 mA.
(CT Radiograph)

BRAIN PERFUSION CT:
The radiologist will determine the scan range, referring to any pre
The injection rate and volume of contrast directly affects the dura
these factors and patient cardiac output for appropriate scan delay
If a second location is desired, the start location of this group will

Perfusion computations are performed on an image-processing wo

Option 1: Axial mode (non-continuous axial acquisitions).

GE	LightSpeed and BrightSpeed 4/8 slice	LightSpee BrightSpeed
Scan Type	Axial	Axial
Rotation Time (s)	1	1
Detector Rows	16	16
Exam Duration (s)	44	44
Total Exposure Time (s)	22	22
kVp	80	80
Manual mA	150	150
AutomA/SmartmA	OFF	OFF
SFOV	Head	Head
Prep Delay (s)	5	5
ISD (s)	1	1
DFOV (cm)	25	25
Image Thickness	5mm x 4i	5mm x
Interval (mm)	0	0
Reconstruction Algorithm	Standard	Standa
ASiR		
Coverage (mm)	20	20
Temporal Sampling (s)	2	2
CTDI-vol (mGy)	200 @ 150 mA	220 @ 15

BRAIN PERFUSION CT (Selected PHILIPS Scanners)

GENERAL: These protocol parameters should not be used for pediatric patients.

CONTRAST: **Oral:** None.
IV: For Non-Jog scans: 40–50 mL contrast, followed by 20–40 mL saline
For Jog Mode scans: 70 mL contrast, followed by 45 mL saline
For all scans: Injection rate of 4–6 mL per second, 18–20 gau

Option 1: Non-Jog Mode.

	Brilliance 16 slice	Brilliance 40/64 slice	
Rotation Time (s)	0.5	0.5	
Collimation	16 × 1.5 mm	32 × 1.25 mm	32
Coverage (mm)	24	40	
kVp	90	80	
mAs	125	125	
ACS/DOM	OFF	OFF	
Cycle Time (s)	2.0	2.0	
Cycles	30	30	
Thickness (mm)	6.0	5.0	
Increment (mm)	0.0	0.0	
Resolution	Standard	Standard	
FOV (mm)	250	250	
Filter	UB	UB	
WC/WL	80/40	80/40	
CTDI-vol (mGy)	240	132	

Option 2: Jog Mode (Table moves back and forth between two position

	Brilliance 16 slice	Brilliance 40/64 slice	
Rotation Time (s)	0.5	0.5	
Collimation	16 × 1.5 mm	32 × 1.25 mm	32
Coverage (mm)	48	80	
kVp	90	80	
mAs	125	125	
ACS/DOM	OFF	OFF	
Cycle Time (s)*	4	4	
# of Jog Cycles	15	15	
Thickness (mm)	6.0	5.0	
Increment (mm)	0.0	0.0	
Resolution	Standard	Standard	
FOV (mm)	250	250	
Filter	UB	UB	
WC/WL	80/40	80/40	
CTDI-vol (mGy)	120	66	

* Cycle time represents the time from the start of one scan to t
over the same piece of anatomy (i.e., the sampling interval of t
For the 4 s cycle time, the manufacturer's perfusion analysis s
rather than absolute, perfusion parameters. Absolute, quantita
are reported for cycle times less than or equal to 2.5 s.

BRAIN PERFUSION CT (Selected TOSHIBA Scanners)

GENERAL: This protocol may include an optional, non-contrast-enhanced head scan and/or an optional head CT angiogram
Center the table height, such that the external auditory meatus is located at the center of the gantry.

CONTRAST: **Oral:** None.
IV: 50 mL of 370 mg/cc concentration contrast media @ 5-6 mL/sec followed by 50 mL saline at 5-6 mL/sec
Preferred injection site: 18–20 gauge IV placed in right antecubital vein

SCANOGRAM: PA and Lateral, 240 mm coverage, 120 kV, 50 mA. caudo-cranial direction.
(CT Radiograph)

BRAIN PERFUSION CT:
This scan is performed for 60 seconds.
The radiologist will determine the scan range, referring to any previously-acquired (optional) scanned series for the Aquilion
Premium. For the Aquilion ONE, the entire head is covered.

Toshiba	Aquilion Premium	Aquilion ONE
Scan Type	Dynamic Volume Intermittent	Dynamic Volume Intermittent
Rotation Time (s)	0.75	0.75
Table Motion	None	None
Collimation	160 x 0.5mm	320 x 0.5 mm
Coverage per Rotation (mm)	80	160
Scan Range (mm)	80	160
Acquisition Interval*	2 s initially, then 5 s	2 s initially, then 5 s
kVp	80	80
mA*	150	300 (arterial phase), 150 (elsewhere)
SURE Exposure	OFF	OFF
Scan Field (mm)	240	240
Delay after injection (s)	7	7
Scan Time (s)	53	53
CTDI-vol (mGy)	122	162

RECONSTRUCTION	Aquilion Premium	Aquilion ONE
Start	Radiologist selects location	Below base of skull
End		Vertex
Kernel	41	41
Slice (mm)	0.5	0.5
Increment (mm)	0.5	0.5
FOV (mm)	240	240

Perfusion computations are performed on an image-processing workstation after scan completion.

*The image below shows the scan protocol for the Aquilion ONE. Each green bar represents a volume scan. The mA is increased for
the arterial portion of the scan to provide improved image quality for the digitally subtracted angiogram (DSA) image.
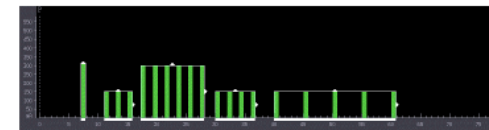
CT Dose Check Feature

- New MITA Standard

- Intended to serve as safety feature on new scanners

- Two levels of dose checking:
  - Alert: 1Gy
  - Notification: By exam

- Dose check levels will be adjustable by site

- Scanners to be delivered with initial default values

CT Scanner Terminology Lexicon

Generic description	GE	PHILIPS	SIEMENS	TOSHIBA	HITACHI
Automatic exposure control (AEC) system	Available in Auto-mA	Available in DoseRight Automatic Current Selection (ACS)	Available in CARE Dose4D	SURE Exposure	Available in IntelliEC
X-ray tube modulation around patient x, y	SmartScan (CT/i only)	D-DOM (Dose Modulation)	CARE Dose	not available as a separate item	Adaptive mA
X-ray tube modulation in longitudinal (z) direction	AutomA	Z-DOM	not available as a separate item (automatically used in head exams)	SURE Exposure	n/a
X-ray tube modulation system in all dimensions (x, y, and z)	SmartmA (x, y, z)	Work in progress	available in CARE Dose4D	SURE Exposure 3D (X, Y and Z Modulation)	IntelliEC

Spearheaded by Thalia Mills, FDA

Technologist Education

- Scanners are increasingly complex
- Current training models are insufficient
  - Train one or two lead techs
  - Expect them to train group of techs
- Techs often dis-incentivized to understand as protocols are locked down more securely
- Future? Internet based training potential?