3RD CT DOSE SUMMIT:
STRATEGIES FOR CT SCAN PARAMETER OPTIMIZATION
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Abdomen-Pelvis CT protocols

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DISCLOSURES

Dianna:

GE Healthcare – “In Kind” research project (Dual-Energy CT)

Rendon:

GE Healthcare - Consultant

Approach

- Routine abdomen-pelvis CT & kidney stone CT
  - Review ACR CT Dose Index Registry Data
  - Review audience sample protocols
  - Compare to AAPM & speaker's protocols
  - Data specific to one vendor (GE)
  - General tips

ACR CT DOSE INDEX REGISTRY

CT ABDOMEN-PELVIS with IV contrast

Highest CTDIvol of all passes recorded

Data reported July-Dec 2012 from ~ 200 facilities

- ACR database includes nearly 200,000 exams
- Average CTDIvol 17 mGy, Std Dev 18 mGy
- MD Anderson contributed ~2300 exams
- Average CTDIvol 19 mGy, Std Dev 7 mGy

ACR CT DOSE INDEX REGISTRY

CT ABD PELVIS KIDNEY CALCULUS

Highest CTDIvol of all passes recorded

Data reported July-Dec 2012 from ~ 200 facilities

- ACR database includes nearly 22,000 exams
- Average CTDIvol 16 mGy, Std Dev 9 mGy
- MD Anderson contributed 6 exams
- Average CTDIvol 19 mGy, Std Dev 4 mGy

Routine Abdomen Pelvis CT: AAPM protocol

Indications (include but are not limited to)

- Evaluation of abdominal, flank, or pelvic pain
- Evaluation of known or suspected abdominal or pelvic masses or fluid collections
- Evaluation of primary or metastatic malignancies
- Evaluation of abdominal or pelvic inflammatory processes
- Evaluate infections of the abdomen and pelvis
- Evaluate patients with fever or suspected abscess
- To identify the cause of bowel obstruction
- Evaluation of weight loss
- Clarification of findings from other imaging studies or laboratory abnormalities.
- For reference, see ACR–SPR Practice Guideline for the Performance of Computed Tomography (CT) of the Abdomen and Computed Tomography (CT) of the Pelvis

Diagnostic Tasks (include but are not limited to)

- Detect soft tissue masses and abnormal fluid collections and determine sizes
- Identify abnormal collections of blood
- Identify air outside the intestinal tract
- Detect nodules or soft tissue masses adjacent to vascular structures
- Detect calcifications in abnormal locations or in abdominal and pelvic organs
- Characterize soft tissue edema around the organs of the abdomen and pelvis

https://aapm.org/pubs/CTProtocols

AAPM Protocol Document

Importance of tailoring abdomen-pelvis CT protocols to size can not be over emphasized.

	Approx. Weight (kg)	Approx. Weight (lbs)	Approx. CTDIvol (mGy)
Small Patient	50-70	110-155	10-17
Average Patient	70-90	155-200	15-25
Large Patient	90-120	200-265	22-35

GE User (n=1):

Routine abdomen/pelvis CT protocol

GE LightSpeed 16
Routine Abd/Pelvis CT

Parameter	User	AAPM
Rotation time	0.5 sec	0.5 sec
Detector configuration	16 x 1.25 mm	16 x 1.25 mm
Pitch	1.375	1.375
kV	120	120
Noise Index & Img Thickn	11.57 & 5 mm	11.57 & 5 mm
Algorithm	Standard	Standard
Additional recons?	?	1.25 mm
Iterative Recon?	Not Available	Not Available

GE LightSpeed 16
Routine Abd/Pelvis CT

Parameter	User	MDA DFOV≤40cm	MDA DFOV≥42cm
Rotation time	0.5 sec	0.8 sec	0.8 sec
Detector configuration	16 x 1.25 mm	16 x 1.25 mm	16 x 1.25 mm
Pitch	1.375	0.938	0.938
kV	120	120	140
Noise Index & Img Thickn	11.57 & 5 mm	10 & 5 mm	12 & 5 mm
Algorithm	Standard	Standard	Standard
Additional recons?	?	2.5 mm & 1.25 mm	2.5 mm & 1.25 mm
Iterative Recon?	Not Available	Not Available	Not Available

Max CTDIvol 32 mGy

Max CTDIvol 41 mGy

KEY FEATURES MDA GE 64-SLICE ABD-PELVIS CT PROTOCOLS:

HD750:

- **DFOV ≤ 40cm: 5mm STD (No ASiR), NI 12, mA 200-580, max CTDIvol 36mGy**
- **DFOV ≥ 42cm: 5mm STD (No ASiR), NI 14, mA 200-770, max CTDIvol 48mGy**

VCT:

- **DFOV ≤ 40cm: 5mm STD (No ASiR), NI 10, mA 200-580, max CTDIvol 36mGy**
- **DFOV ≥ 42cm: 5mm STD (No ASiR), NI 12, mA 200-770, max CTDIvol 48mGy**

ALL: 120kV, 0.8 sec, 64 x 0.625mm, pitch 0.984, 2.5mm@20% ASiR, 0.625mm for reformats

GE LightSpeed 16
Routine Abd/Pelvis CT at Duke

Parameter	Duke	AAPM
Rotation time	0.5 sec	0.5 sec
Detector configuration	16 x 0.625 mm	16 x 1.25 mm
Pitch	1.75	1.375
kVp	120	120
Noise Index & Slice Thickness	15 HU & 5 mm	11.57 HU & 5 mm
Algorithm	Standard	Standard
Additional recons?	0.625 mm	1.25 mm
Iterative Recon?	Not Available	Not Available

GE VCT 64
Routine Abd/Pelvis CT at Duke

DukeMedicine

Parameter	Duke	AAPM
Rotation time	0.5 sec	0.5 sec
Detector configuration	64 x 0.625 mm	64 x 1.25 mm
Pitch	1.375	1.375
kVp	120	120
Noise Index & Slice Thickness	15 HU & 5 mm	11.57 HU & 5 mm
Algorithm	Standard B	B/C
Additional recons?	0.625 mm	0.625 mm
Iterative Recon?	Not Available	Not Available

GE 750 HD 64
Routine Abd/Pelvis CT at Duke

DukeMedicine

Parameter	Duke	AAPM
Rotation time	0.5 sec	0.5 sec
Detector configuration	64 x 0.625 mm	64 x 1.25 mm
Pitch	1.375	0.984
kVp	120	120
Noise Index & Slice Thickness	22 HU & 5 mm	25.2 HU & 5 mm
Algorithm	Standard B	B/C
Additional recons?	0.625 mm	0.625 mm
Iterative Recon?	ASiR (40% Blend)	ASiR (50% Blend)

GE LightSpeed 16
Renal Stone CT at Duke

Parameter	Duke	AAPM (Routine Abd/Pel)
Rotation time	0.5 sec	0.5 sec
Detector Configuration	16 x 0.625 mm	16 x 1.25 mm
Pitch	1.75	1.375
kVp	120	120
Noise Index, Slice Thickness	15 HU, 5.00 mm	11.57 HU & 5 mm
Filter	Standard B	Standard
Additional Recons?	0.625 mm	1.25 mm
Iterative Recons?	Not Available	Not Available

GE VCT 64
Renal Stone CT at Duke

DukeMedicine

Parameter	Duke	AAPM (Routine Abd/Pel)
Rotation time	0.5 sec	0.5 sec
Detector Configuration	64 x 0.625 mm	64 x 1.25 mm
Pitch	1.375	1.375
kVp	120	120
Noise Index, Slice Thickness	17.5 HU, 5.00 mm	11.57 HU, 5.00 mm
Filter	Standard B	B/C
Additional Recons?	0.625 mm	0.625 mm
Iterative Recons?	Not Available*	Not Available*

GE HD 750 64
Renal Stone CT at Duke

DukeMedicine

Parameter	Duke	AAPM (Routine Abd/Pel)
Rotation time	0.5 sec	0.5 sec
Detector Configuration	64 x 0.625 mm	64 x 1.25 mm
Pitch	1.375	0.984
kVp	120	120
Noise Index, Slice Thickness	25 HU, 5.00 mm	25.2 HU, 0.625 mm
Filter	Standard B	B/C
Additional Recons?	0.625 mm	0.625 mm
Iterative Recons?	ASiR (40% blend)	ASiR (50% blend)

CTDI Chart According To Patient Size GE Scanners at Duke

Patient Width	CTDI vol (mGy) 16-Slice	CTDI vol (mGy) VCT	CTDI vol (mGy) 750 HD
■ 25 cm	9 (5 - 14)	7 (3 - 10)	4 (2 - 5)
■ 30 cm	13 (7 - 20)	12 (6 - 17)	6 (3 - 9)
■ 35 cm	19 (9 - 28)	21 (10 - 31)	10 (5 - 15)
■ 40 cm	26 (18 - 55)	37 (18 - 55)	17 (8 - 25)

Mean CTDI
Comparison of ACR & Duke Data

DukeMedicine

	Mean ACR CTDI vol	Mean Duke CTDI vol (all patients)	Mean Duke CTDI vol (since 2012)
■ # Exams / # Pts	---	877 / 311	1053 / 403
■ Abd/Pel CT w IV	17 ± 18	15.9 ± 7.1	14.3 ± 7.4
■ Renal Stone CT	16 ± 9	15.3 ± 8.6	12.8 ± 8.6

Converting DLP to mSv

Region of body	Normalized effective dose E_{DLP} (mSv mGy^{-1} cm^{-1})
▪ Head	0.0023
▪ Neck	0.0054
▪ Chest	0.017
▪ Abdomen	0.015
▪ Pelvis	0.019

Huda W. Pediatr Radiol. 2002; 32:272-279.

Converting DLP to mSv

- Example (brain):
  - CTDI 13.57 (one slice)
  - DLP (14.25 cm)= 193.46 mGy-cm
  - 193.46 x 0.0023 = 0.44 mSv

Exam Description: CT BRAIN

Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	-	-	-	-
2	Axial	I31.000-S106.525	13.57	193.46	Head 16
			Total Exam DLP:	193.46	

Converting DLP to mSv

- Example (abdomen & pelvis):
  - CTDI 10.0 (one slice)
  - DLP (50 cm)= 500 mGy-cm
  - 500 x 0.015* = 7.5 mSv
  - (300 x 0.015) + (200 x 0.019) = 8.3 mSv

WATCH OUT FOR…

- Fastest rotation speed (0.4 sec) produces more artifacts
- There is a delay if the rotation speed is changed between sequential scan sets within a series (for example, CAP)
- No IQ difference with respect to the order images are generated (“acquire thin images, recon thick images”)
- NI is **VERY dependent** on the FIRST set of images generated (acquired)
- May be more efficient work-flow to generate thin images first if reformats are to be produced (do that while waiting on delayed scan for example)
- LOTS of details can be programmed and saved for each protocol

Philips Users:

Routine abdomen/pelvis (n=3) &

kidney stone (n=1) CT protocols

PHILIPS BRILLIANCE 64
ROUTINE ABD/PELVIS CT

Parameter	User	AAPM
Rotation time	0.75 sec	0.5 sec
Detector Configuration	32 x 1.25 mm	64 x 1.25 mm
Pitch	0.906	0.75
kV	120	120
AEC on? (DoseRight)	Yes	Yes
Image Thickness	3.75 mm	5 mm
Filter	Standard B	B/C
Additional recons?	-	3 mm, 0.9 mm

Siemens Users:

Routine abd/pelvis CT (n=6) &

Kidney stone CT (n=4) Protocols

Siemens Sensation 64
Routine Abd/Pelvis CT and Kidney Stone CT

Parameters	Abd/Pelvis	Kidney Stone
Rotation time	0.5 sec	0.5 sec
Detector Configuration	24 x 1.2 mm	24 x 1.2 mm
Pitch	0.9	1.5
kV	120	100
Quality Ref. mAs	180	180
Image thickness	5 mm	3 mm
Kernel	B31f	B31f
Iterative Recon?	No	No

Siemens Definition FLASH 64
Routine Abdomen/Pelvis CT at Duke

DukeMedicine

Parameters	Duke	AAPM
Rotation time	0.5 sec	0.5 sec
Detector Configuration	64 x 0.6 mm	64 x 0.6 mm
Pitch	0.8	0.6
kVp	120	120
Quality Ref. mAs	200	210, 150 (with IR)
Image thickness	5.0 mm, 3.0 mm, 0.6 mm	5.0 mm, 1.0 mm
Kernel	I31	B30f
Iterative Recon?	Safire (Power 2.0)	Safire (Power 3.0)

Siemens Definition FLASH 64
Renal Stone CT at Duke

DukeMedicine

Parameters	Duke	AAPM (Routine Abd/Pel)
Rotation time	0.5 sec	0.5 sec
Detector Configuration	64 x 0.6 mm	64 x 0.6 mm
Pitch	0.8	0.6
kV	120	120
Quality Ref. mAs	200	210, 150 (with IR)
Image thickness	5.0 mm, 3.0 mm, 0.6 mm	5.0 mm, 1.0 mm
Kernel	I31	B30f
Iterative Recon?	Safire (Power 2.0)	Safire (Power 3.0)

CTDI Chart According To Patient Size Siemens Scanners at Duke

DukeMedicine

Patient Width	Definition FLASH
■ 25 cm	6 (3 - 9) mGy
■ 30 cm	8 (4 - 11) mGy
■ 35 cm	10 (5 - 15) mGy
■ 40 cm	12 (6 - 19) mGy

Toshiba users:

Abd/Pelvis CT (n=1)

Routine Abdomen-Pelvis CT

Parameter	User	AAPM
Rotation time	0.5 sec	0.5 sec
Detector configuration	80 x 0.5 mm	160 x 0.5 mm
Pitch	0.813	Std. (0.869)
kV	120	120
Standard Deviation	Standard	Std. (12.5)
Image Thickness	5 mm	5 mm
Sure IQ Setting	Body Std. Axial, FC18	Body Std. Axial
Iterative Recon?	AIDR3D	?

KIDNEY STONE CT PROTOCOL @ MGH

For follow-up kidney stone exams performed at MGH:

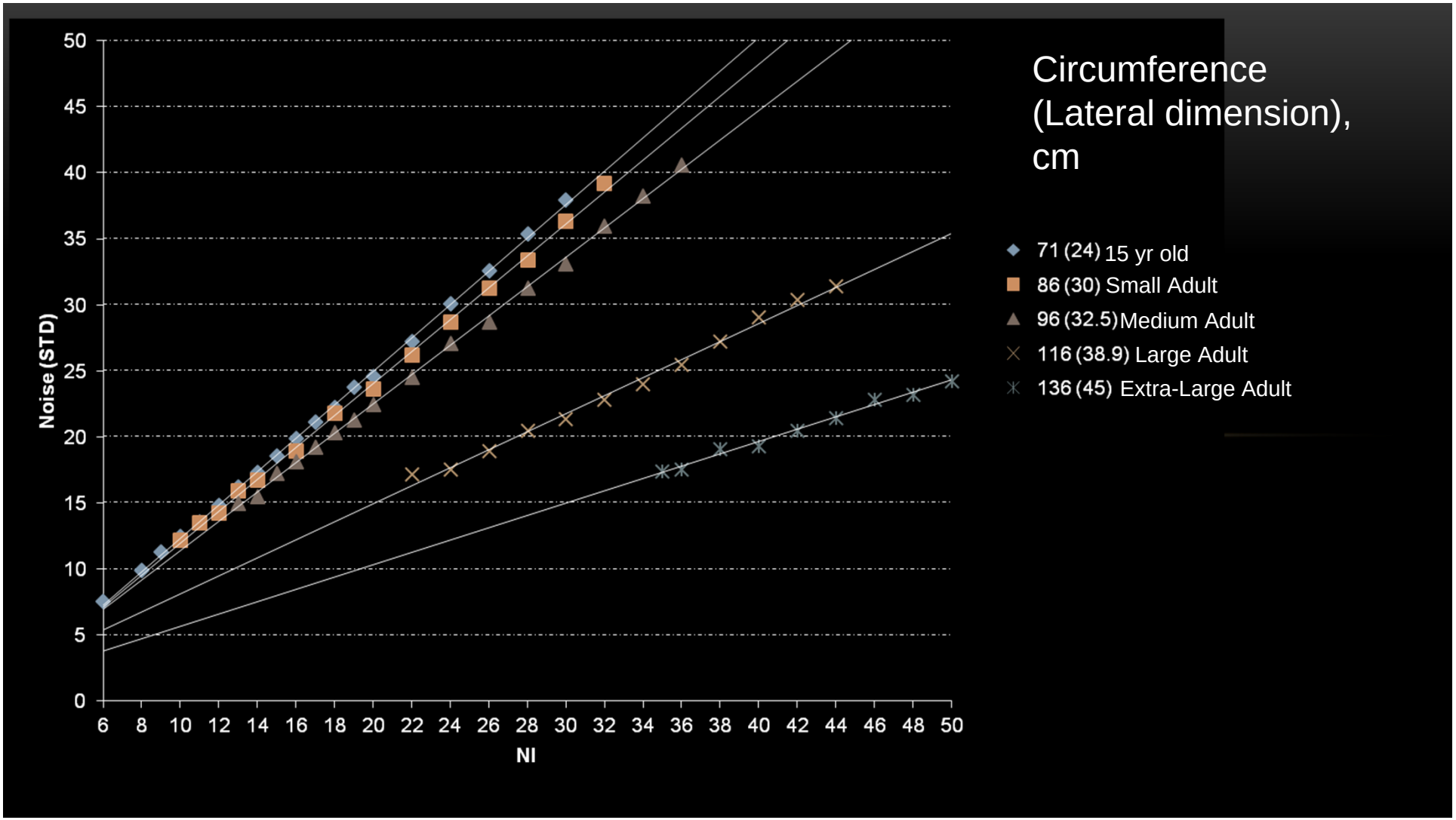
- Dose reduced by 30-50% relative to routine abd/pelvis scan
- NI increased from 13-15 up to 20 if no ASiR is available
- NI increased from 13-15 up to 25 with 50% ASiR
- NI increased from 13-15 up to 30 with 60% ASiR
- NEW protocol uses 80kV & 150mA & VEO (<1 mSv)

5mm Images

KIDNEY STONE PROTOCOL @ MAYO

- Prior to 2010, used an initial screening kidney stone protocol with quality reference mAs of 240 (routine abd/pelvis) & a follow-up kidney stone protocol QRM of 160
- 2010 decision was made to use only the lower technique for all kidney stone exams
- Has worked well for nearly three years
- Established at all Mayo sites (MN, AZ, FL)
- Kidney Stone protocol is 33% reduced from routine abd/pelvis protocol

Courtesy of Jim Kofler, Ph.D.


Noise (STD)
NI
0
5
10
15
20
25
30
35
40
45
50
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
Circumference (Lateral dimension), cm
71 (24) 15 yr old
86 (30) Small Adult
96 (32.5) Medium Adult
116 (38.9) Large Adult
136 (45) Extra-Large Adult

Salient points in Abdomen-Pelvis CT protocols

- Strongly recommend AEC for routine abd-pelvis CT
  - Be aware of potential pitfalls (TCM talk!)
- Be stingy with extra phases like routine delayed phase
  - Both in doing it and in the technique used
- Apply iterative reconstruction if available
  - May not improve IQ until dose is decreased substantially

Salient points in Kidney Stone CT protocols

- Kidney stone CT protocols should be done at reduced dose relative to routine abdomen-pelvis scans!
- Especially follow-up exams for kidney stones!!
- ~ 30% lower dose than routine abdomen-pelvis scan is a good target