image gently®

The Alliance for Radiation Safety in Pediatric Imaging

第6回　九州CT研究会
平成26年5月17日(Sat)
ナースプラザ福岡

小児領域における被ばく低減機能とその効果

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アウトライン

- 小児CT被ばくの現状
- 各パラメータについて

  Bowtie filter, kV, mA, AEC, Active collimator
- 小児CTの被ばく評価
- まとめ

小児CT ガイドライン（2005年）

要約

✓ 小児は放射線に対する感受性が成人の数倍高い。

✓ 体格が小さいため、成人と同様の撮影条件では、
臓器あたりの被ばく量は2倍から5倍になる。

✓ CT検査に当たっては、適応を厳密に検討し、
小児のための撮影プロトコールを適用する。

✓ 医師は検査の必要性を患児、家族に十分説明する。

ALARA原則

- 達成可能な限り低線量で撮影すべきである
- 線量を低減させることは大切だが、診断できる画質を維持しなければならない。

1：体格に合ったプロトコルを選択する

2：AECなどの機能を利用する

3：低管電圧も検討

4：逐次近似再構成の利用

AJR FOCUS ON:

Pediatric CT: Strategies to Lower Radiation Dose

2013.May

- CT Dose Metrics

  ⇒CTDIvol, DLP, Effective dose, SSDE

- Image Quality vs Dose

  ⇒kV, mA, Pitch, Collimation

- Dose reduction tools

  ⇒AEC, Adaptive collimator, Bowtie filter

- Post processing methods

  ⇒Iterative reconstruction

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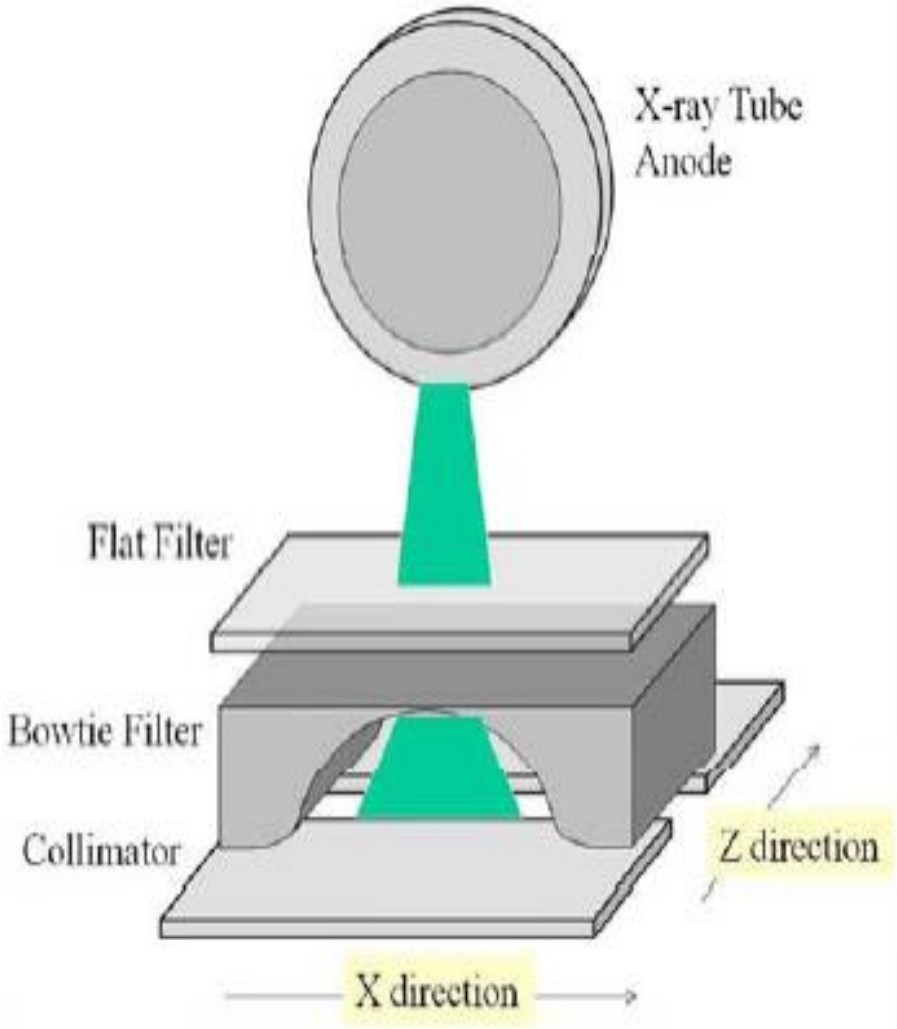
Bowtie filterとは



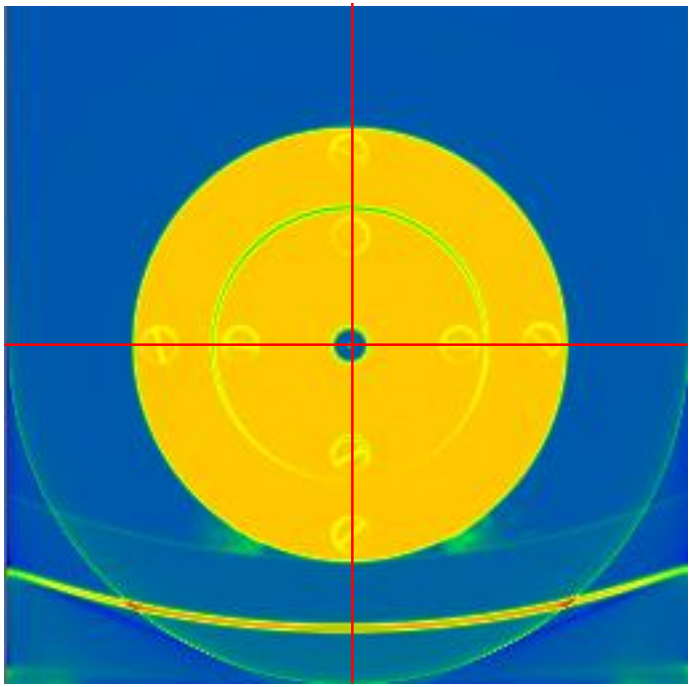
Bowtie filterの影響

CT dose reduction in practice. Pediatric Radiology 2011; 41:488–492

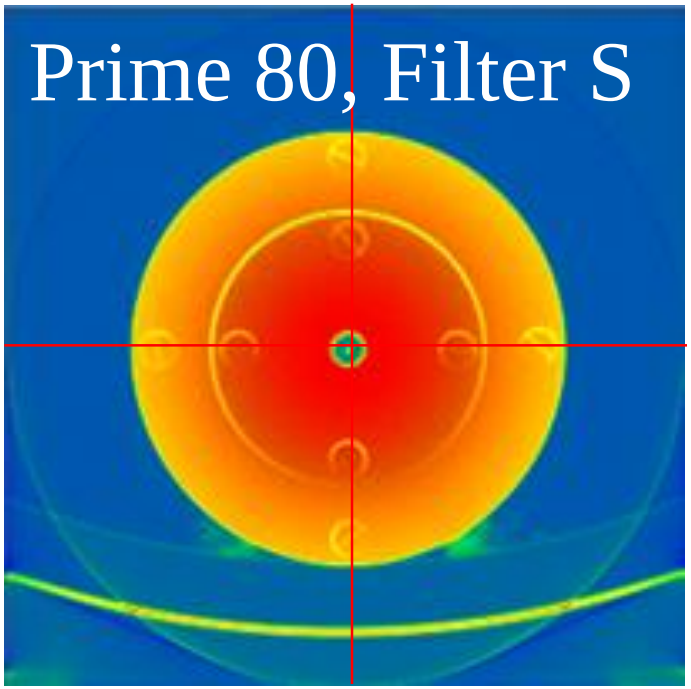
⇒ This leads to increased image quality

and a 50% reduction in surface dose.

フィルタ無し



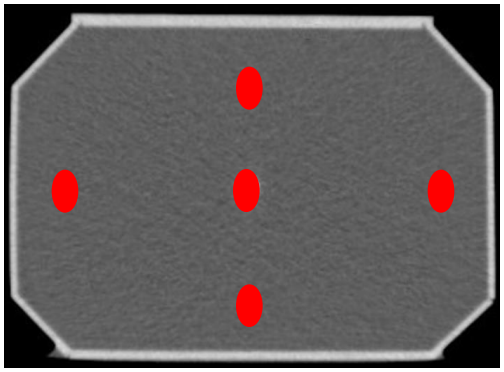
フィルタ有り



Bowtie filterと体幹部の関係

Filter FOV	0 10x16 cm	1 11x16 cm	5 14x22 cm	10 15x24c m	15 17x27c m	20 20x30 cm
S 24 cm	○	○	×	×	×	×
M 32 cm	○	○	○	○	×	×
L 40 cm	○	○	○	○	○	○

被ばくの違い：Filter S vs L



CTDI volume 統一

S 120kV

L 120kV

Absorbed dose [mGy]

15
14
13
12
11
0

Center UP Lt Rt LOW

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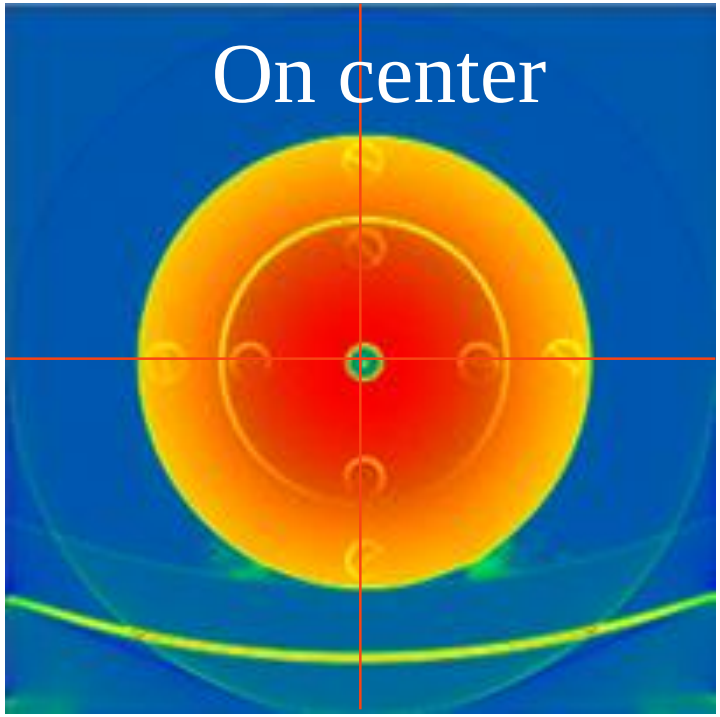
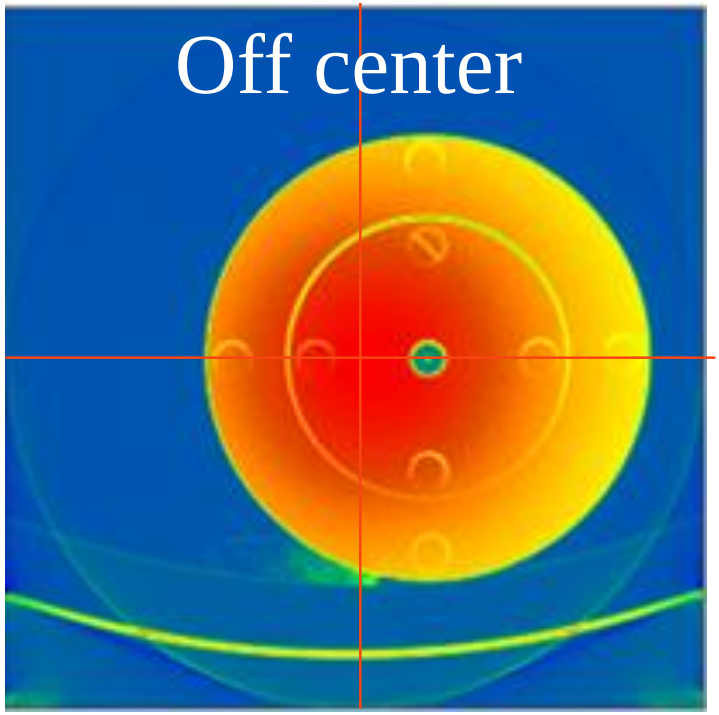
Bowtie filterの影響

Automatic patient centering for MDCT: effect on radiation dose.
AJR 2007; 188:547–552

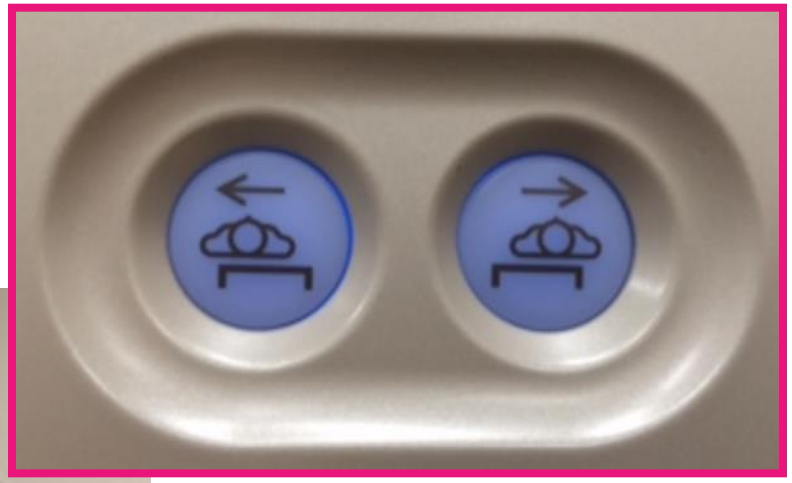
Surface CTDI values increased by approximately 41–49% when the phantom was30 and 60 mm off center, respectively

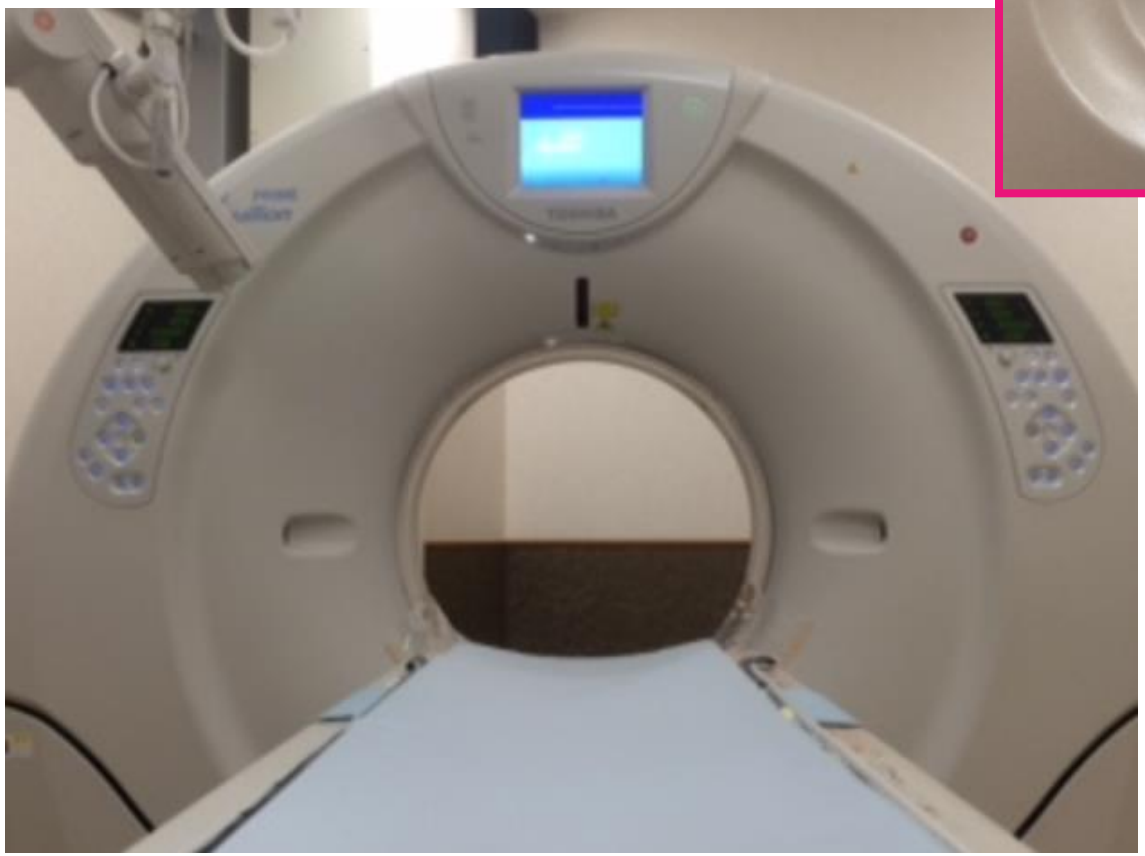




こんなのも被ばく低減機能になる

寝台シフト機能





- Positioning the patient in the middle of the CT gantry reduces the radiation dose to the patient according to the inverse-square law.

- Image Gently: ten steps you can take to optimize image quality and lower CT dose for pediatric patients.

  AJR 2010; 194:868–873

- Callahan MJ. CT dose reduction in practice.

  - Pediatric Radiology 2011; 41:488–492

- 線源から離す（中心に寝かす）

Korean Journal of Radiology
KJR

CT Radiation Dose Optimization and Estimation: an Update for Radiologists

Hyun Woo Goo, MD
Department of Radiology and Research Institute of Radiology, Asan Medical Center, University of Ulsan College of Medicine, Seoul 138-736, Korea

2012.Feb

Checkup Items	Recommendations
Body size adapted CT protocol	Traditionally based on body weight or body mass index
	Based on cross-sectional dimensions and/or body attenuation for better dose adaptation to individually varied body habitus
	Use best-fit equation rather than dose table or chart

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The Alliance for Radiation Safety in Pediatric Imaging

Test Procedures | In The News | Parent | Radiologic Technologist | Medical Physicist | Radiologist | Referring Physician | Partners in Industry | Global Resources | FAQs

image gently when we care for kids! The ***image gently*** Campaign is an initiative of the Alliance for Radiation Safety in Pediatric Imaging. The campaign goal is to change practice by increasing awareness of the opportunities to promote radiation protection in the imaging of children.

Image Gently Impact

The image gently campaign launched 1/22/08. This is a snapshot of what has happened since:

18,180 medical professionals have taken the pledge

This website has been visited 391,142 times

The CT protocol has been downloaded over 26,425 times

Click here to take the image gently pledge!

Quick Links

Proof of IG Pledge	Referring Physician
Protocols	Radiologic Technologist

Dr. Thalia Mills-2012 Butterfly Award

On November 26, 2012, Image Gently awarded Dr. Thalia Mills the 2012 Butterfly Award. Click here to read more about Dr. Mills contributions to reducing pediatric radiation dose.

Back to Basics | Butterfly Award | IAEA Video | Posters

TO PARENTS

Recent News

NCRP Report 172 Available

The NCRP Report No. 172, Reference Levels and Achievable Doses in Medical and Dental Imaging: Recommendations for the United States is now available. This Report represents an important continuation of NCRP reports on radiation safety and health protection in medicine and lays the foundation for the development and application of DRLs and achievable doses for diagnostic x-ray

News from Image Wisely

The Minnesota Department of Health is the first state health agency in the count...

Thanks to everyone who has pledged to image wisely, including many this week at...

Attention RSNA attendees! Learn more about new Image Wisely nuclear medicine ini...

Nuclear medicine exams help save and extend lives every day. Our new initiative...

腹部単純プロトコル換算表

Table I: mAs Reduction Factors for the Pediatric Abdomen and Thorax

Room #:		CT Unit:		Date:	
Abdomen	**kVp**	**mA**	**Time (sec)**	**Pitch Abdomen**	**Pitch Thorax**
Baseline:	fill in	fill in	fill in	fill in	fill in
PA		**Abdomen**		**Thorax**	
Thickness (cm)	**Approx Age**	**mAs Reduction Factor (RF)**	**Estimated mAs = BL x RF**	**mAs Reduction Factor (RF)**	**Estimated mAs = BL x RF**
9	newborn	0.43	#VALUE!	0.42	#VALUE!
12	1 yr	0.51	#VALUE!	0.49	#VALUE!
14	5 yr	0.59	#VALUE!	0.57	#VALUE!
16	10 yr	0.66	#VALUE!	0.64	#VALUE!
19	15 yr	0.76	#VALUE!	0.73	#VALUE!
22	small adult	0.90	#VALUE!	0.82	#VALUE!
25	med adult	1.0	fill in	0.91	#VALUE!
31	large adult	1.27	#VALUE!	1.16	#VALUE!

1. Type in baseline abdomen techniques and mAs in yellow cells
2. Spreadsheet will calculate mAs estimated for pediatric patients of varying sizes

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Image gently：2つの手順

- 手順1：大人の頭部と腹部の撮影条件を基準値として定める。

  ⇒被ばく線量　小児　＜　成人

  ⇒AECの使用　　小児　＜　成人

- 手順2：小児の胸部、腹部、頭部の適切 なmAs値を決定する。

  ⇒AECの効果を判定

成人腹部CTの最適条件は？

- デジタルファントムと臨床画像を用いた肝臓領域における低コントラスト分解能の評価

  札幌医科大学　原田耕平 先生　日放技誌　2010

- 今一度　SD10を考える

  大阪医科大学　吉川秀司 先生　第17回CTサミット2013

腹部の特徴

✓成人と比べて、腹腔内の脂肪量が少ない。
✓臓器も小さい。
✓各組織（臓器）の境界が不明瞭となる。

使用機器

- 撮影装置：Aquilion PRIME (Toshiba社)
- 評価ファントム

外枠： 1, 5, 10, 20歳児自作体幹部ファントム

（材質3mmアクリル，内部水封入可）

参考文献

Patient Size Measured on CT Images as a Function of Age at a Tertiary Care Children‘s Hospital

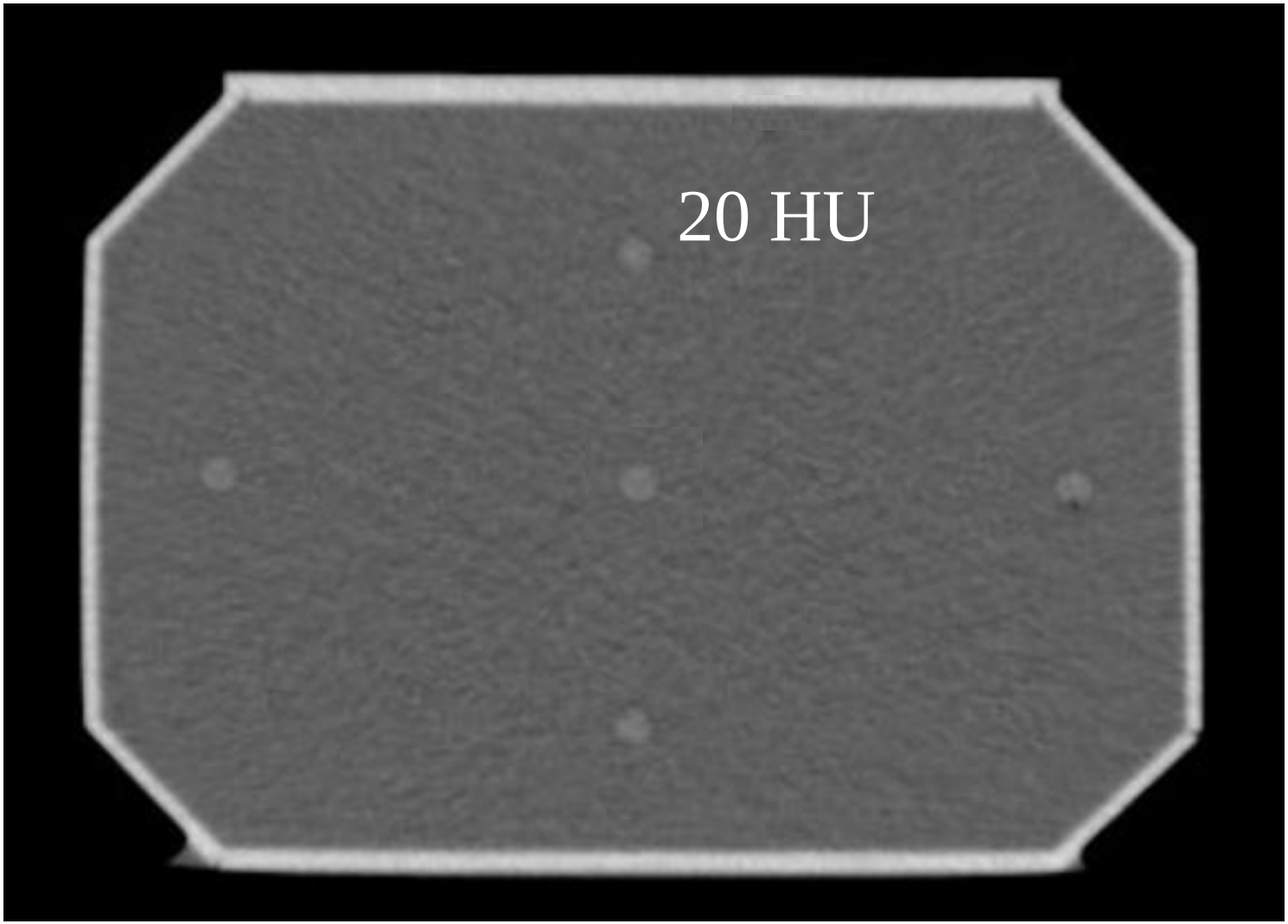
内部モジュール：低コントラストロッド

内容物：ポリビニルアルコール系接着剤

：高コントラストロッド

内容物：希釈造影剤（120 kVにて300HU程度）

Original phantom



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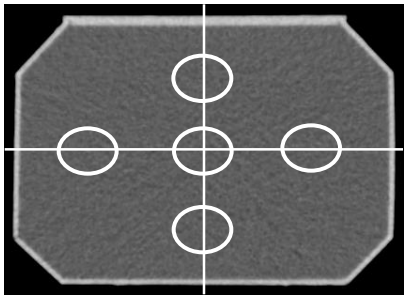
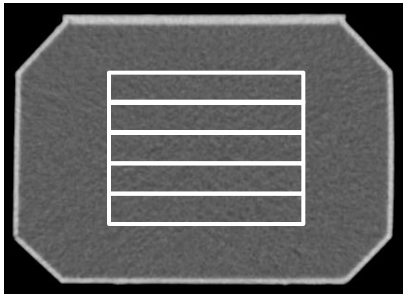
評価方法

Aquilion PRIME
120 kV, Rot time: 0.5s, Colli: 1mm x 40, Pitch: 0.828, Kernel: FC13 FBP Boost on

各ファントム, Filter, mAにおけるmA-SD曲線の作成

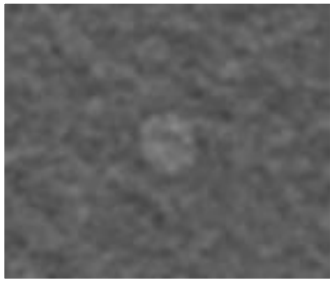


各ファントムにおけるSD10同一条件での画像評価 NPS, CNR

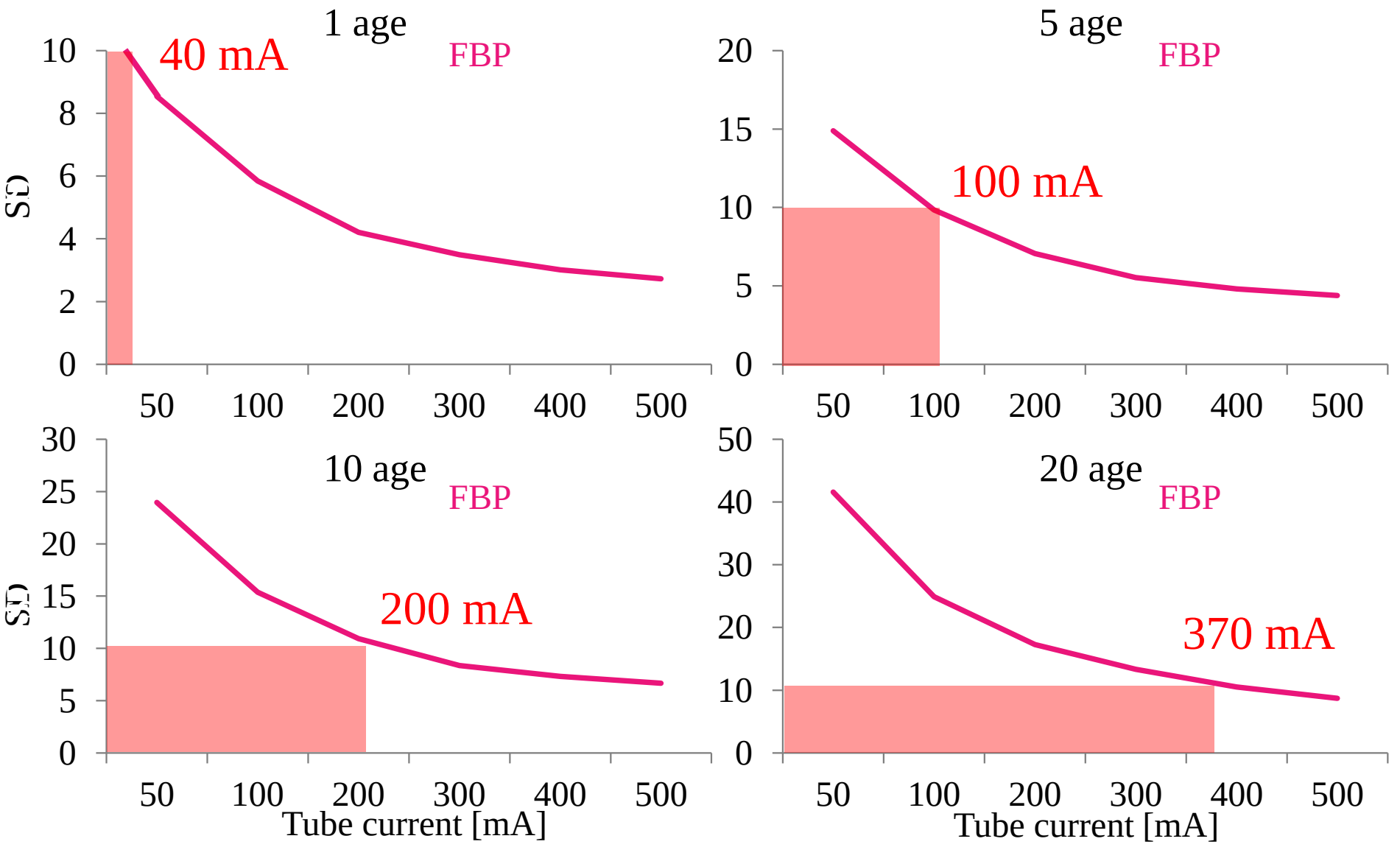


各年齢に対する適正管電流

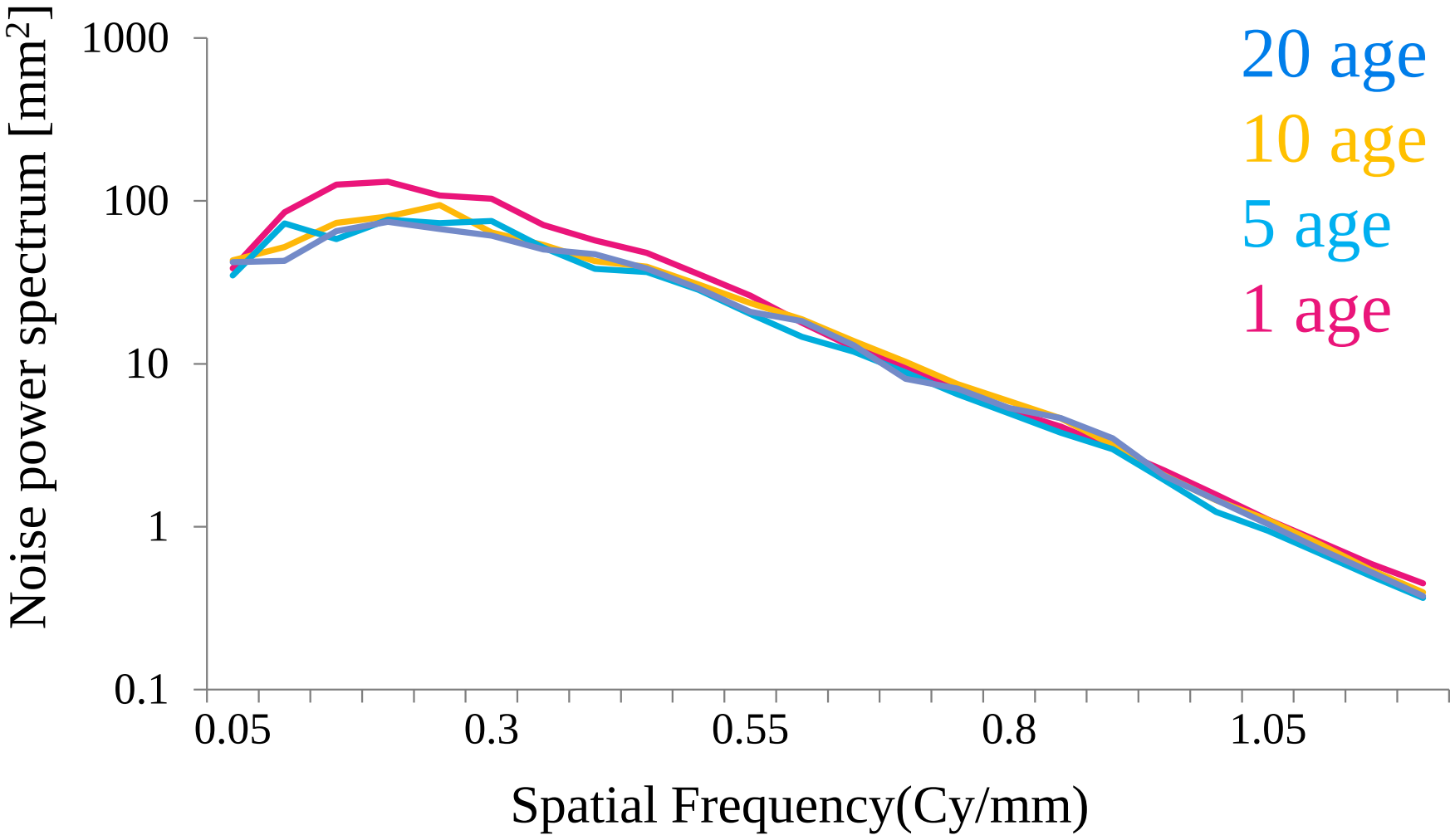
画像の視覚的評価



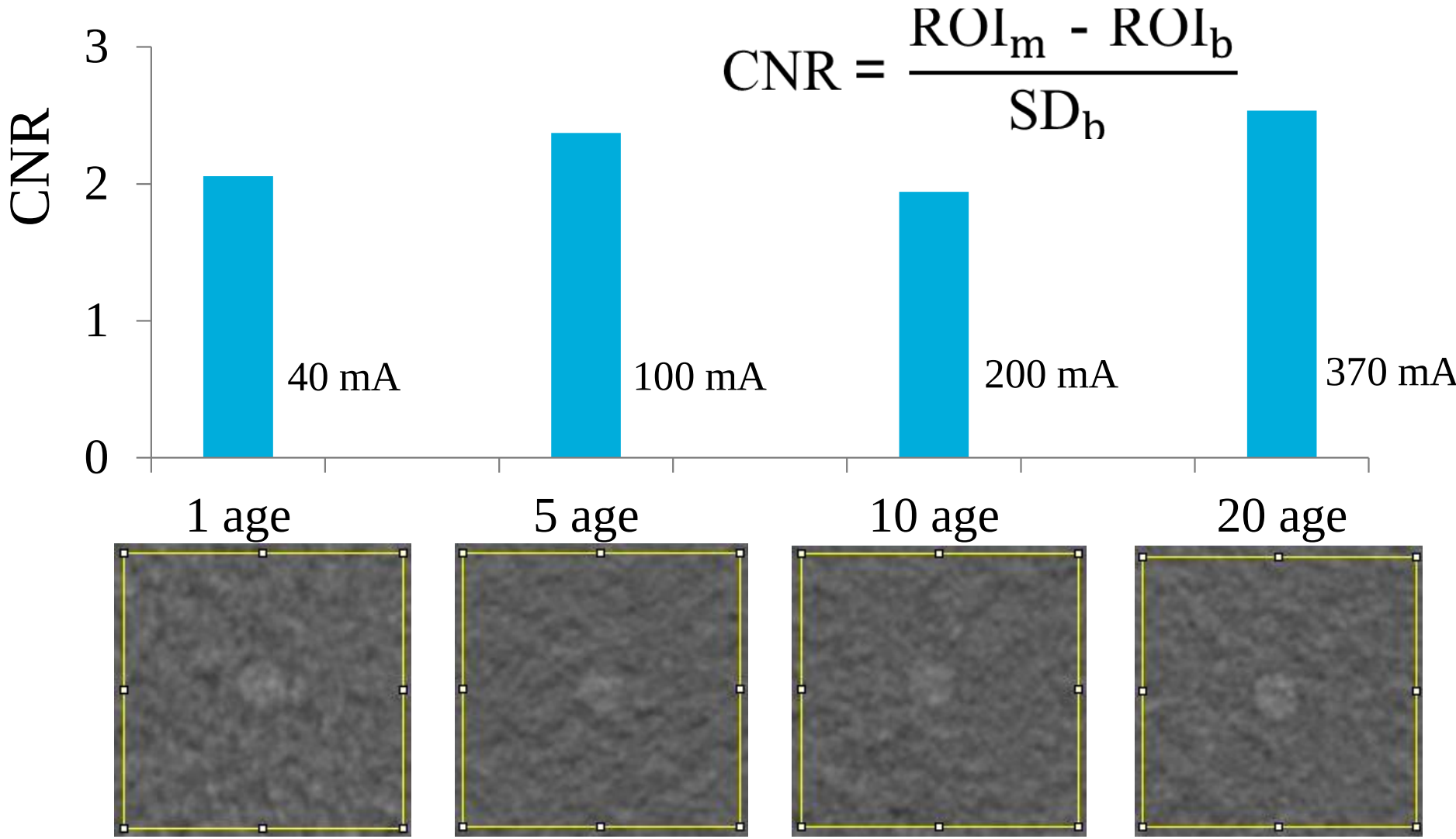
結果：SD-mAの関係


1 age
40 mA
FBP
5 age
100 mA
FBP
10 age
200 mA
FBP
20 age
370 mA
FBP
SD
Tube current [mA]
50
100
200
300
400
500

結果：NPSの比較


Noise power spectrum [mm²]
1000
100
10
1
0.1
0.05
0.3
0.55
0.8
1.05
Spatial Frequency(Cy/mm)
20 age
10 age
5 age
1 age

結果：CNRの比較


CNR = $\frac{ROI_m - ROI_b}{SD_b}$
CNR
3
2
1
0
40 mA
100 mA
200 mA
370 mA
1 age
5 age
10 age
20 age

SD: 10における管電流の比

成人に対する各年齢の管電流の比

Age	Our data	Image gently
1	0.11	0.51
5	0.27	0.59
10	0.54	0.66
15	0.78	0.76
20 Adult	1	1

視覚的評価における管電流の比

成人に対する各年齢の管電流の比

Age	Our data	Image gently
1	0.32	0.51
5	0.43	0.59
10	0.64	0.66
15	0.74	0.76
20 Adult	1	1

視覚的評価から求めた必要SD

Prime 80 におけるmA-SD曲線から求めた

Age	Our data	mA	SD
1	0.32	120	6
5	0.43	160	8
10	0.64	240	9
15	0.74	270	9.5
20 Adult	1	370	10

必要SDの比較

Image gentlyの係数は安全に使用できる！

Age	SD by our data	SD by Image gently
1	6	4
5	8	6
10	9	9
15	9.5	10
20 Adult	10	10

Korean Journal of Radiology
KJR

CT Radiation Dose Optimization and Estimation: an Update for Radiologists

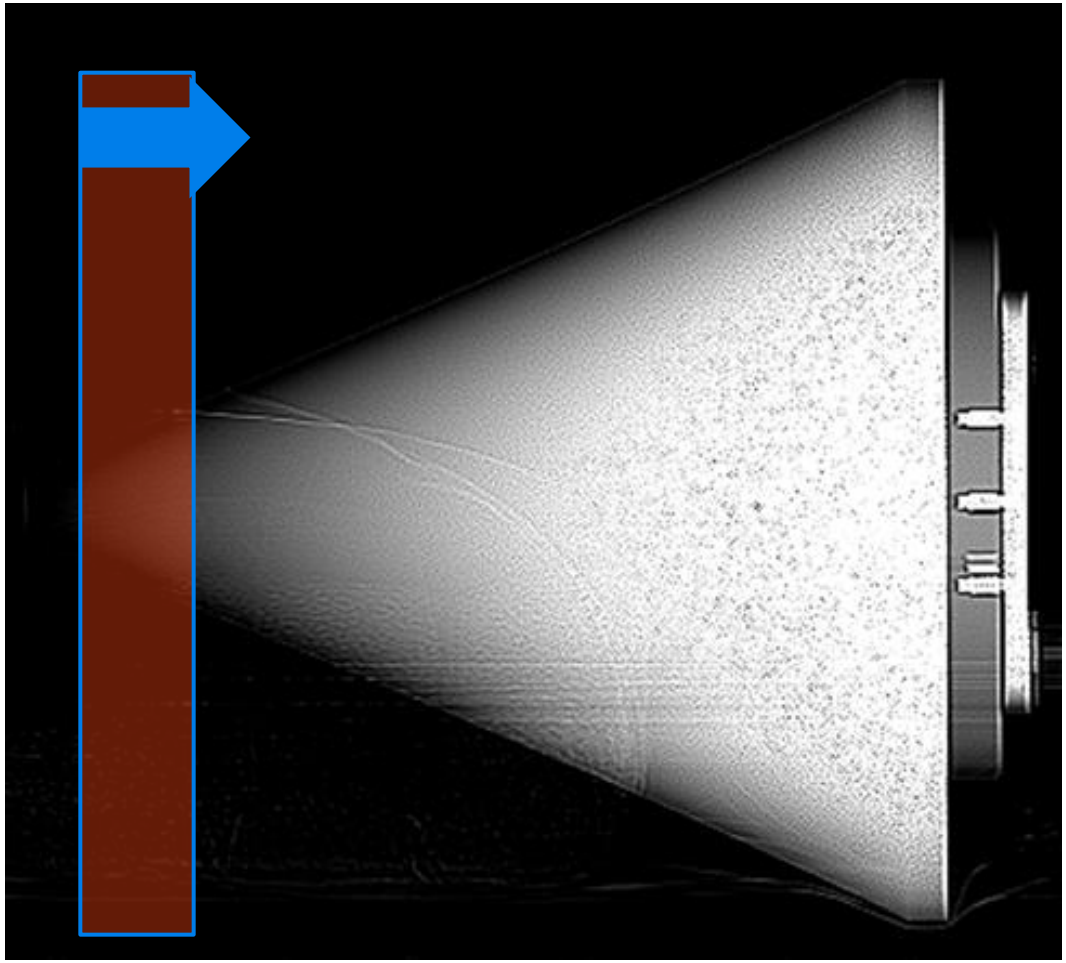
Hyun Woo Goo, MD
Department of Radiology and Research Institute of Radiology, Asan Medical Center, University of Ulsan College of Medicine, Seoul 138-736, Korea

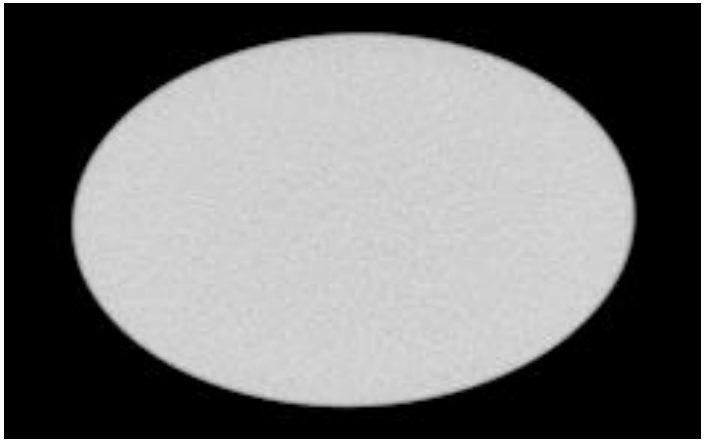
2012.Feb

Checkup Items	Recommendations
Tube current modulation	Always turn on if applicable
	Set up appropriate reference image quality index
	Check how much modulated tube current reaches to maximal limits

AECの評価：楕円ファントム

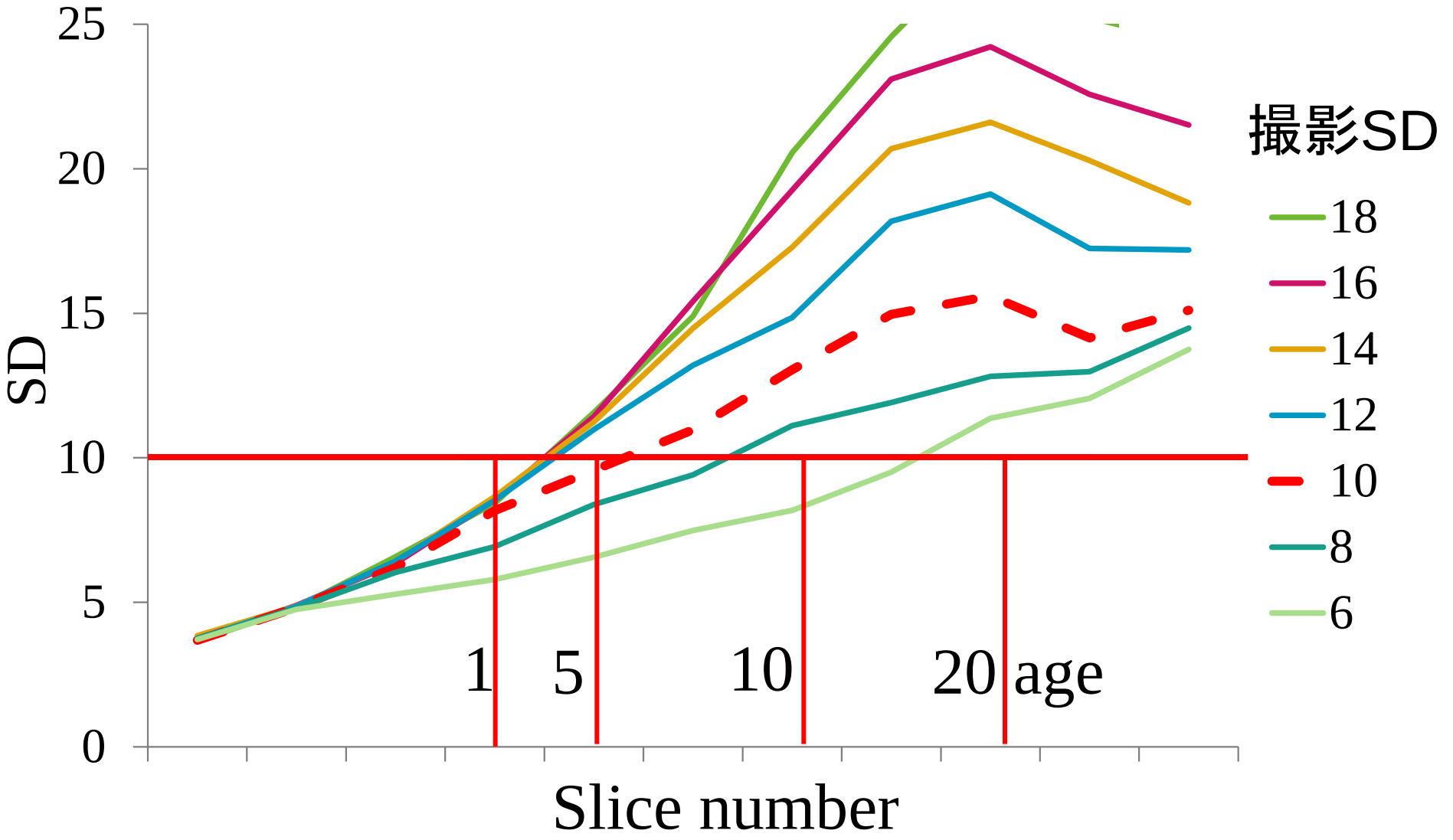
Aquilion PRIME
120 kV, Rot time: 0.5s, Colli: 1mm x 40, Pitch: 0.828, Kernel: FC13 FBP Boost on





縦横比は小児体型
とほぼ同じ

AECを用いたSD-断面積の関係



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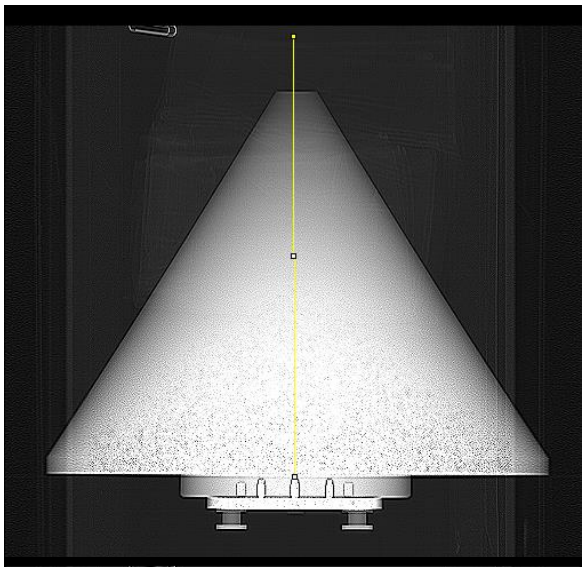
位置決め画像による被ばく低減

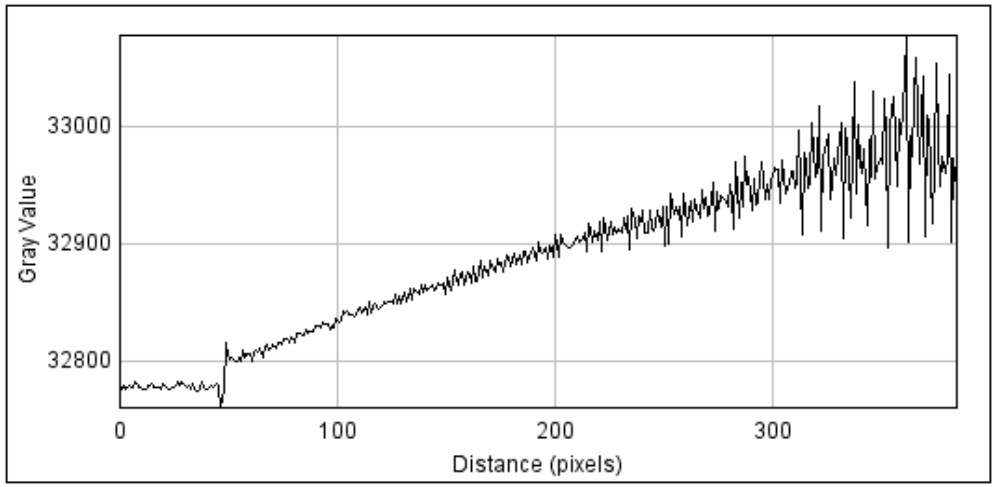
Image Gently: ten steps you can take to optimize image quality and lower CT dose for pediatric patients. AJR 2010; 194:868–873

- The orientation of the topogram from AP to PA in a supine patient.
- This reduces the dose to male gonads, breast, thyroid, and eye lenses.
- By reducing the x-ray beam energy from 120 to 80 kV.

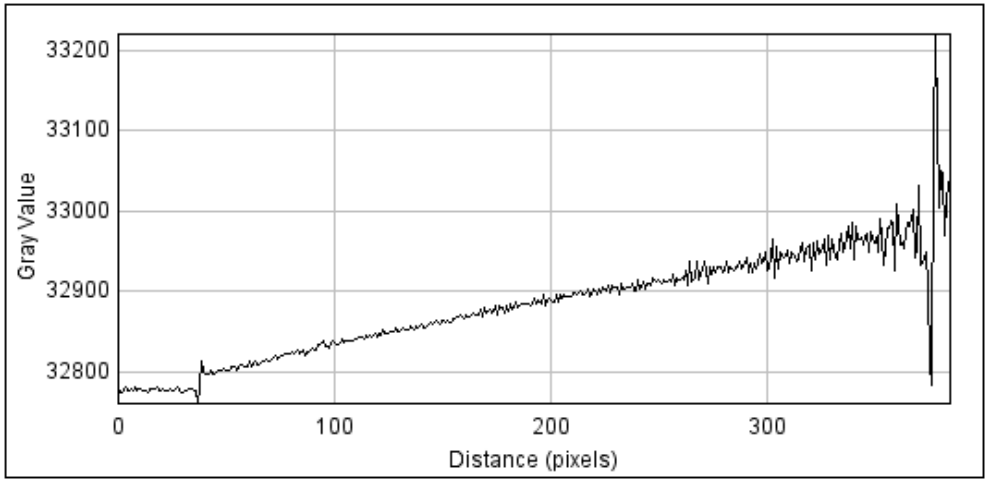
異なる管電圧における位置決め画像

80 kV
Topo





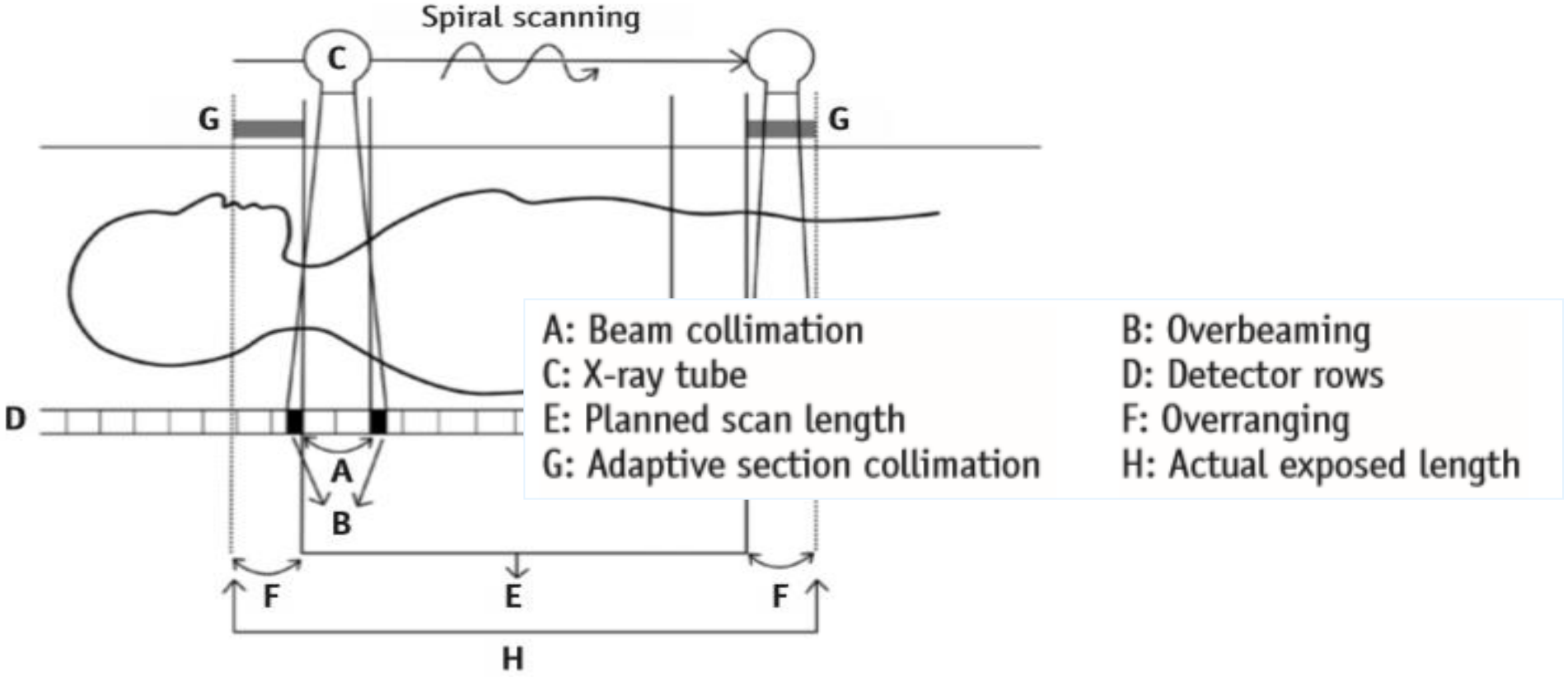
120 kV
Topo



Adaptive Section Collimation

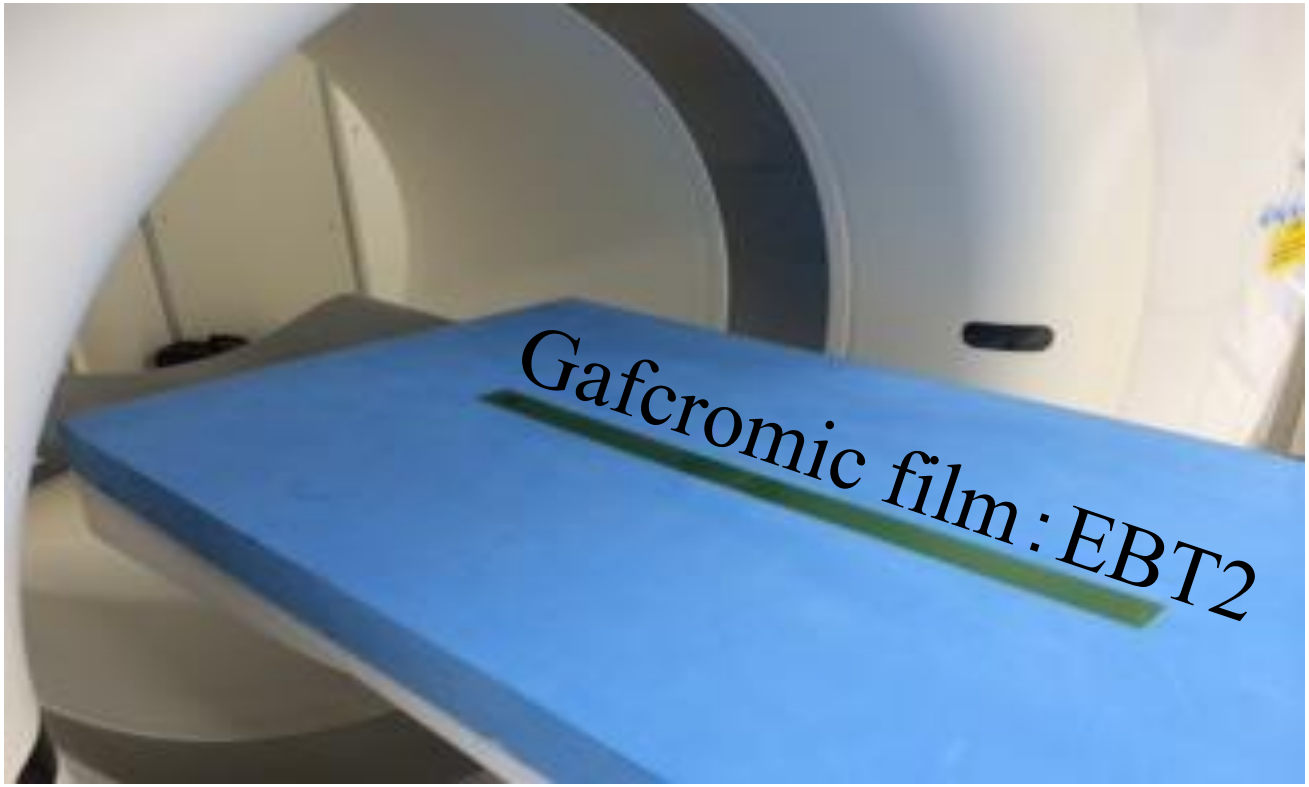
Effects of adaptive section collimation on patient radiation dose in CT.
Radiology 2009; 252:140–147

⇒The dose savings are up to 38% .

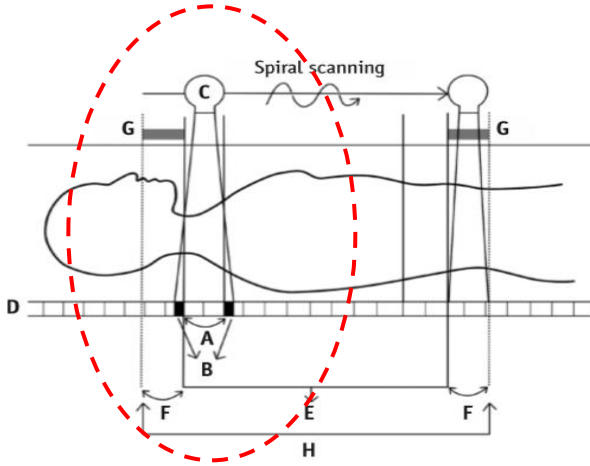


測定方法

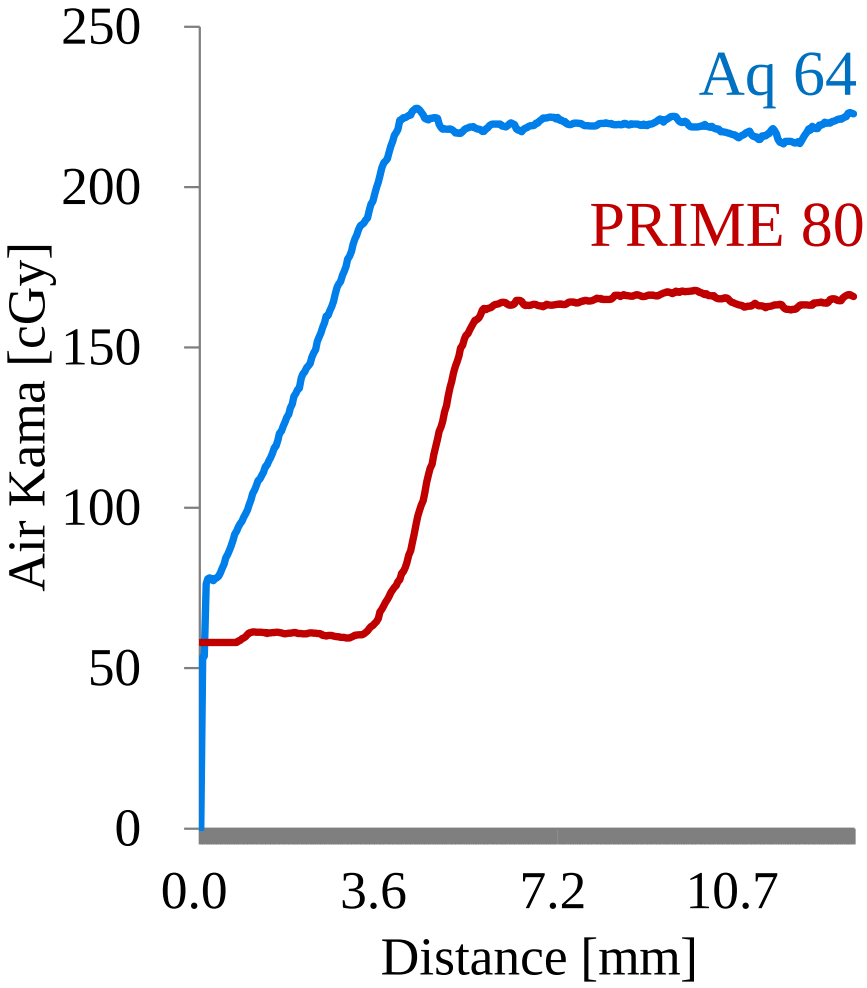
- Aquilion 64 vs Aquilion PRIME
  120 kV, 400mA, Rot time 1.0s, Colli 0.5mmx32
  Scan length 10 cm

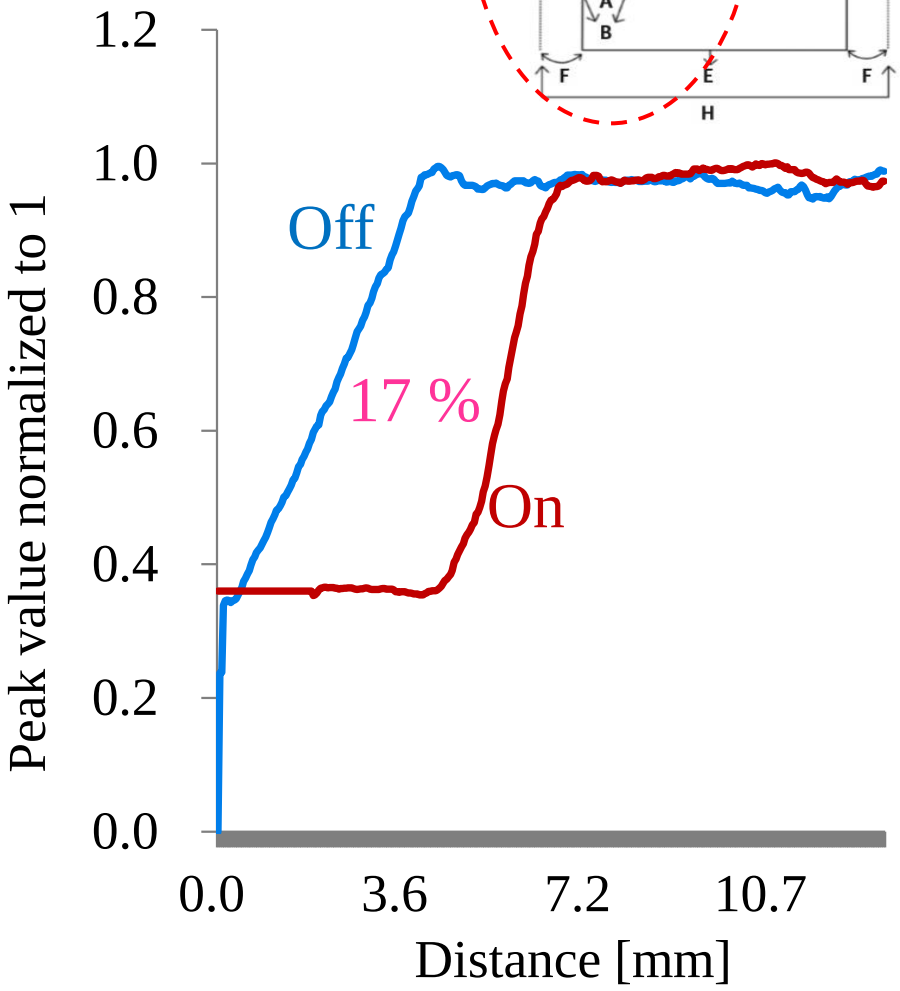


Active collimatorの効果



Pitch 0.828の場合





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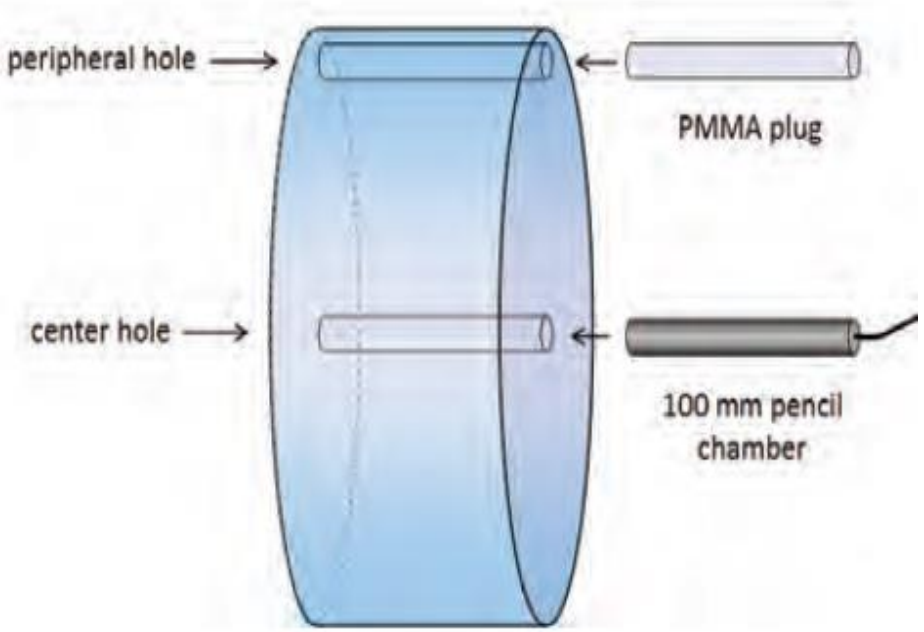
CTの線量測定



10 cm(100 mm)

32 cm: 体幹部用
16 cm: 頭部、小児用

診断参考レベル(Diagnostic Reference Levels)

- 通常の検査において、ある特定の手法から患者の線量または投与された放射能量がその手法の値に対し異常に高いか低いかを示すために画像診断に使用されるもの

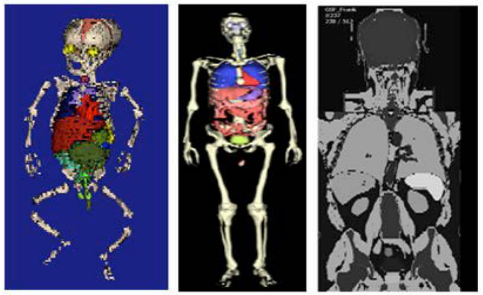
- 医療被ばくガイドライン, 2006 JART
- X線診断時に患者が受ける線量の調査研究, 2011 JSRT
- 我が国の小児CTで患児がうける線量の実態調査 JSRT

Size-Specific Dose Estimates (SSDE) in Pediatric and Adult Body CT Examinations

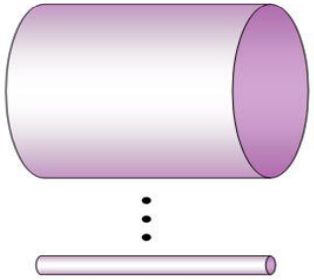
Report of AAPM Task Group 204, developed in collaboration with the International Commission on Radiation Units and Measurements (ICRU) and the Image Gently campaign of the Alliance for Radiation Safety in Pediatric Imaging

A. Physical Anthropomorphic Phantoms
(McCollough and collaborators, Mc)

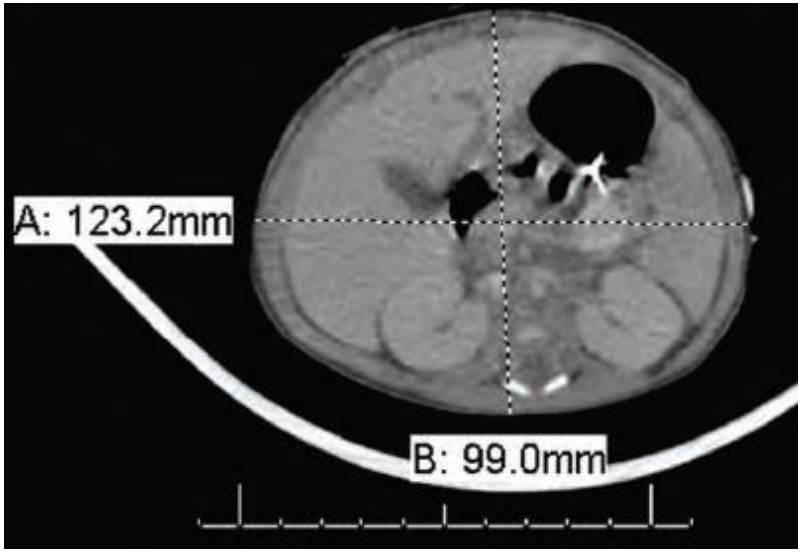
B. Cylindrical PMMA phantoms
(Toth and Strauss, TS)

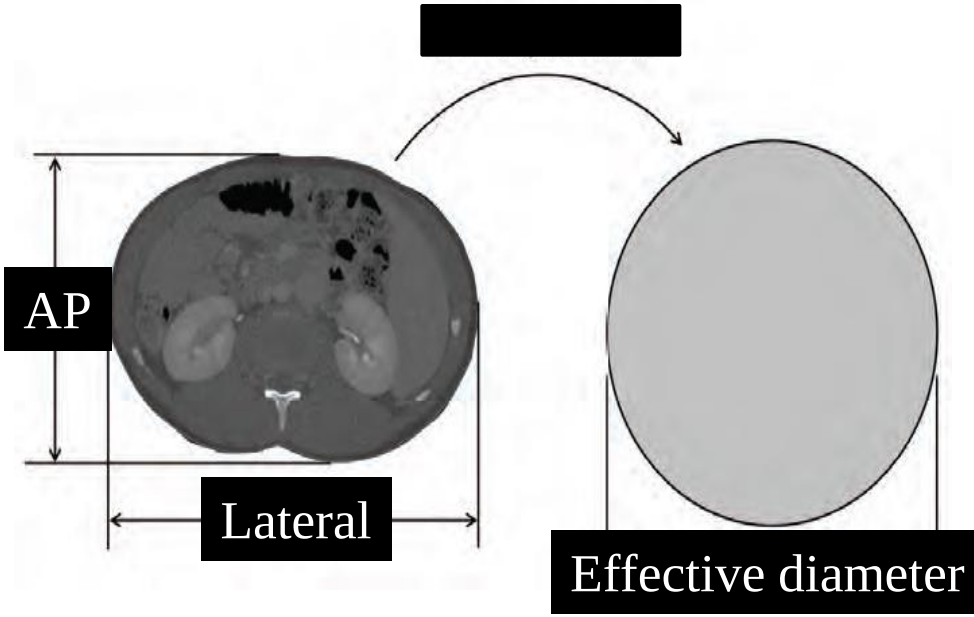


C. Monte Carlo Voxelized Phantoms
(McNitt-Gray and collaborators, MG)



D. Monte Carlo Mathematical Cylinders
(Boone and collaborators, ZB)





$$SSDE = f_{size}^{16X} \times CTDI_{vol}^{16}$$

$$SSDE = f_{size}^{32X} \times CTDI_{vol}^{32}$$

$$5.40\,mGy \times 2.50 = 13\,mGy$$

Lat + AP Dim (cm)	Effective Dia (cm)	Conversion Factor
16	7.7	2.79
18	8.7	2.69
20	9.7	2.59
22	10.7	2.50
24	11.7	2.41
26	12.7	2.32

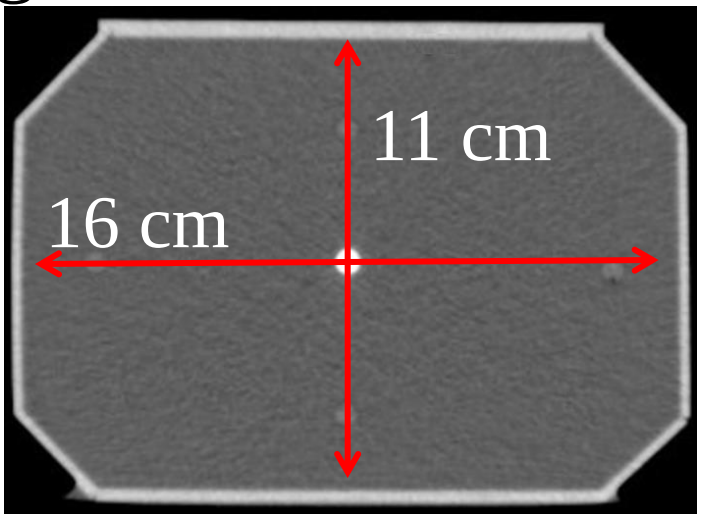
SSDEの検証

Aquilion PRIME by TOSHIBA : Filter M, 0.5 rot/s, Beam width 40 mm

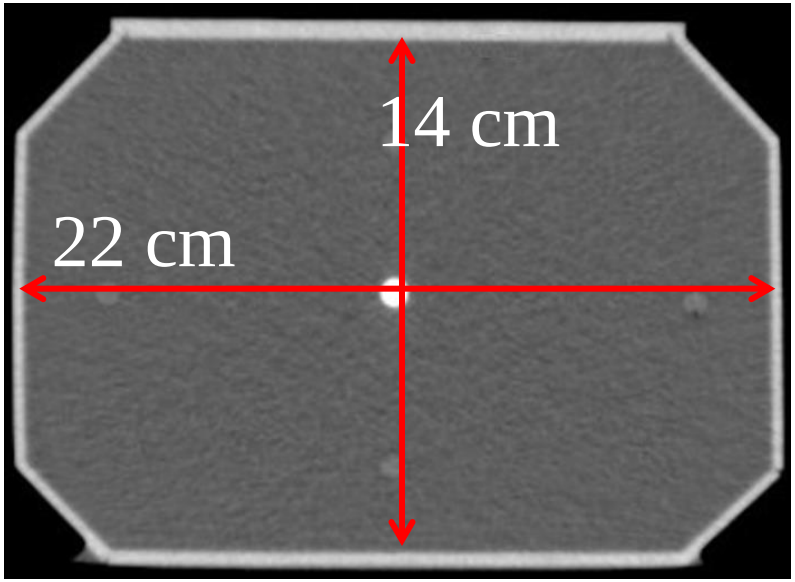
120 kV, 200mA
CTDI vol $_{16\ cm}$: 17.6 mGy
Conversion factor: 1.13
SSDE: 19.9 mGy
Glass: 18.4 mGy

120kV, 200mA
CTDI vol $_{16\ cm}$: 17.6 mGy
Conversion factor: 0.95
SSDE: 16.7 mGy
Glass: 15.9 mGy

1 age



5 age



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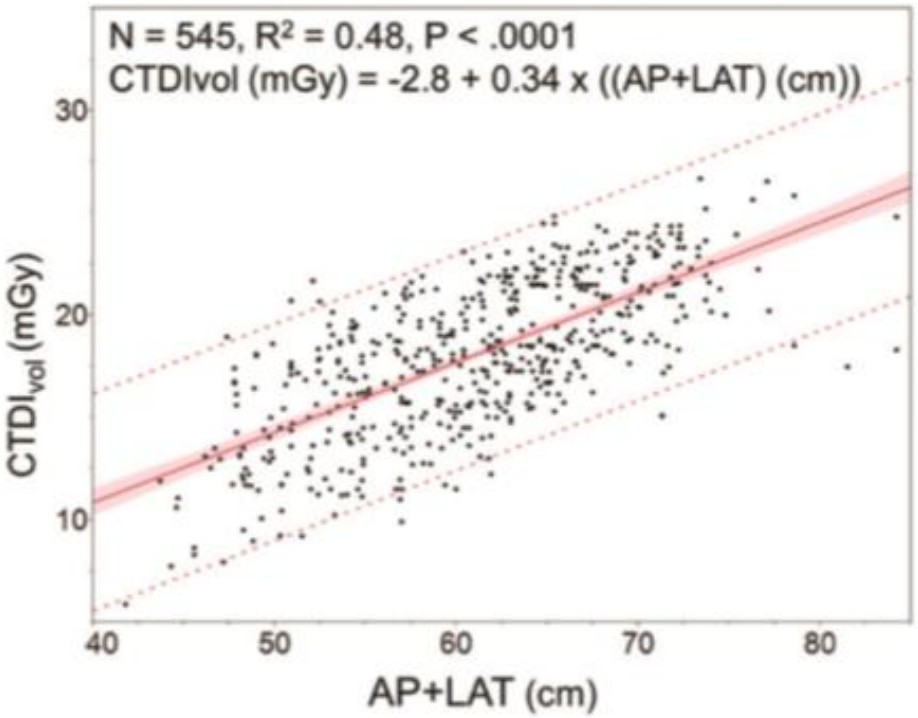
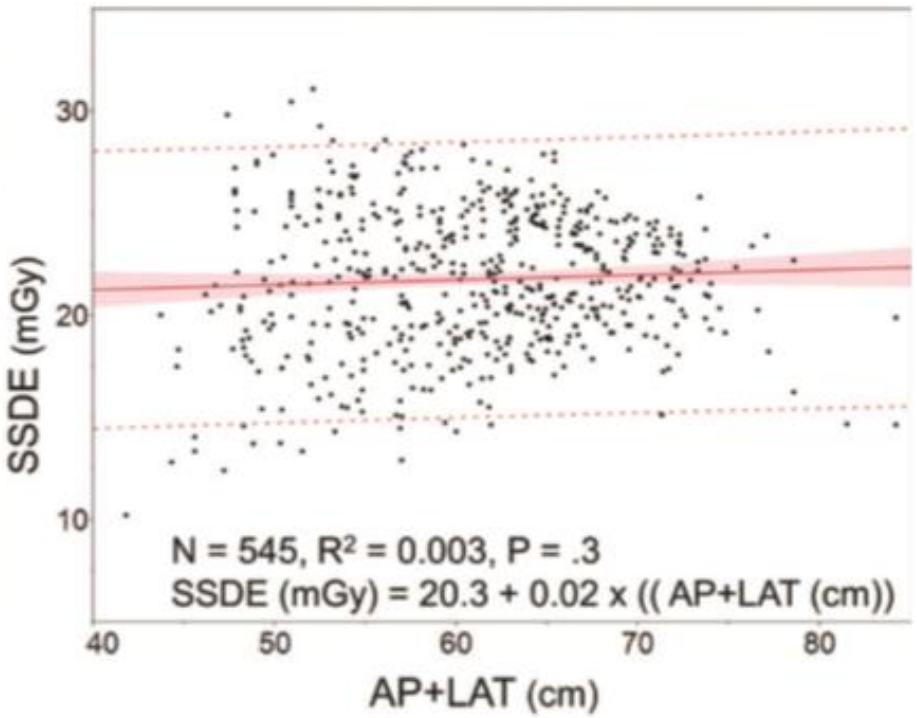
SSDE for adult Patients at CT of the Torso

Radiology 2012

Descriptive Statistics for Patients, CT Scanner Output, and SSDE

Statistic	Age (y)	Age of Women (y)	Age of Men (y)	AP+LAT (cm)	$CTDI_{vol}$ (mGy)	SSDE (mGy)
Mean	62	60	64	61.2	18.1	21.8
Standard deviation	15	16	14	7.4	3.7	3.4





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まとめ

- CT装置に搭載されてる被ばく低減機能について解説した。目の前の被ばく低減機能を使いこなすだけでなく、装置の特性を理解し、体型に合わせたプロトコルを作成することが大切である。