Optimizing Pediatric CT in the Emergency Department

Texas Children's Hospital®

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Outline

- How is the pediatric patient different?
- Pediatric patient age and size
- The most common CT scan in the ER
- Step-by-step approach to establishing pediatric protocols
- Notes for the medical physicist
- Notes for the technologists

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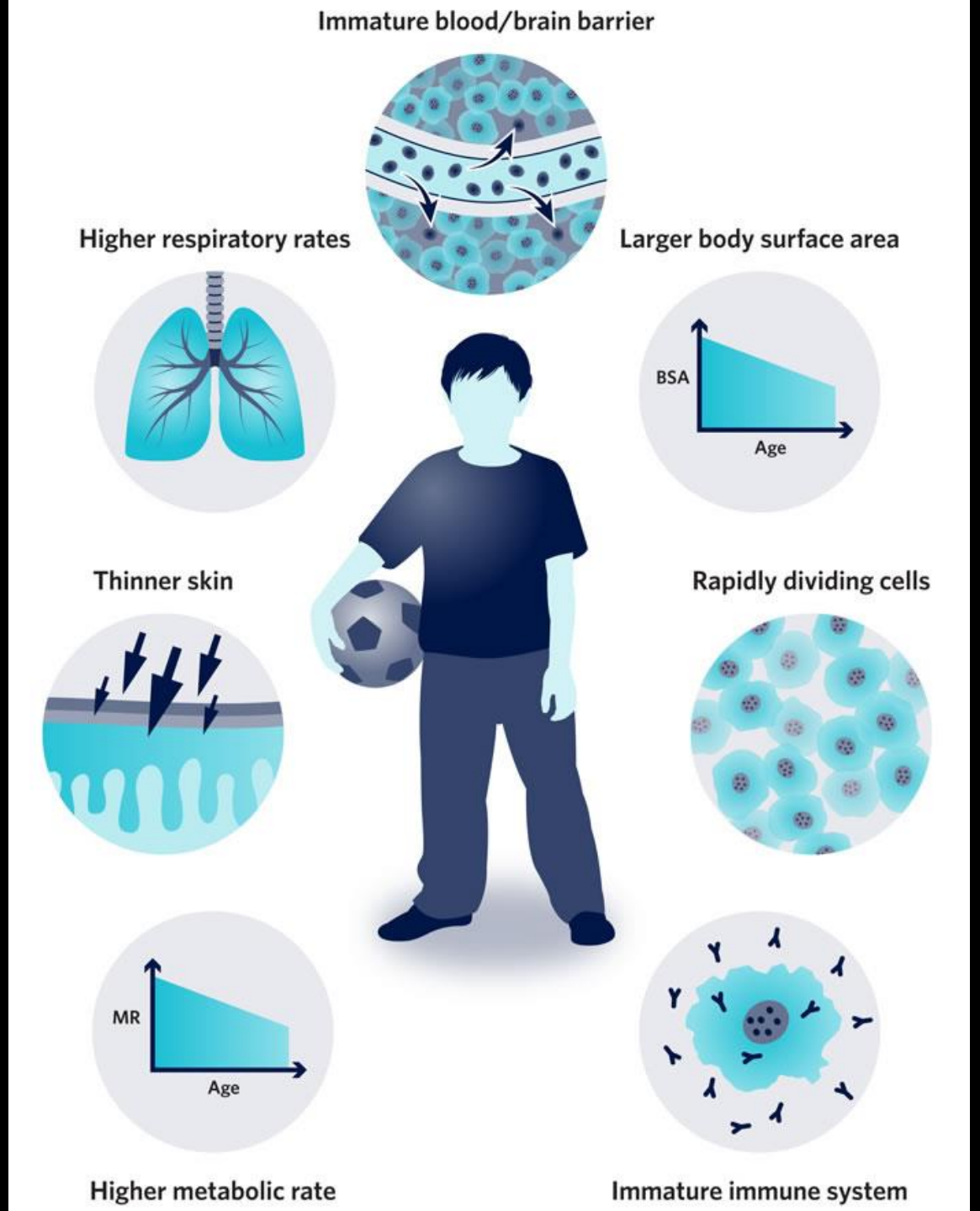
http://www.jisppd.com

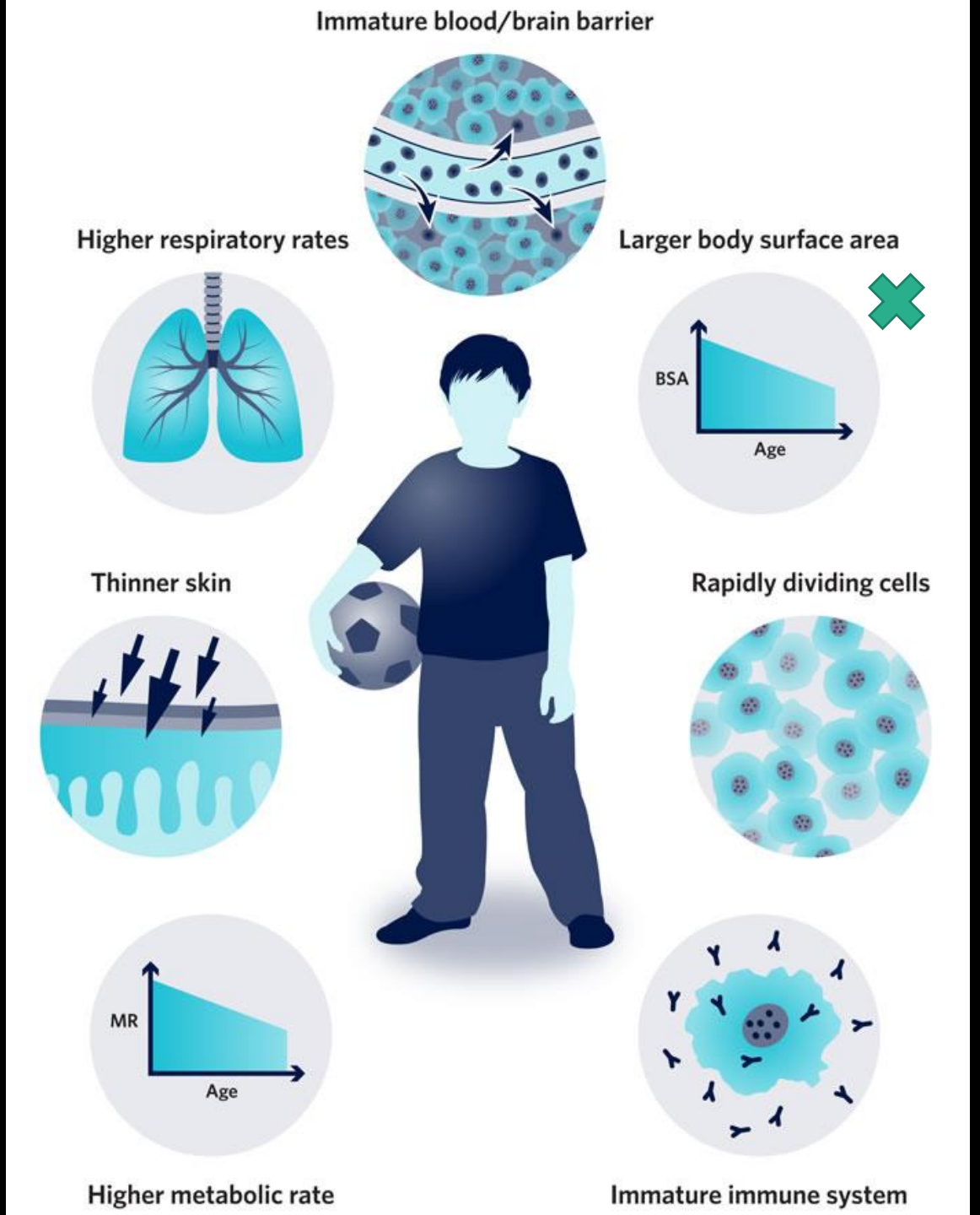


http://www.rch.org.au

BSA 4X of adult

Heat production 1.5X of adult

Higher risk of hypothermia



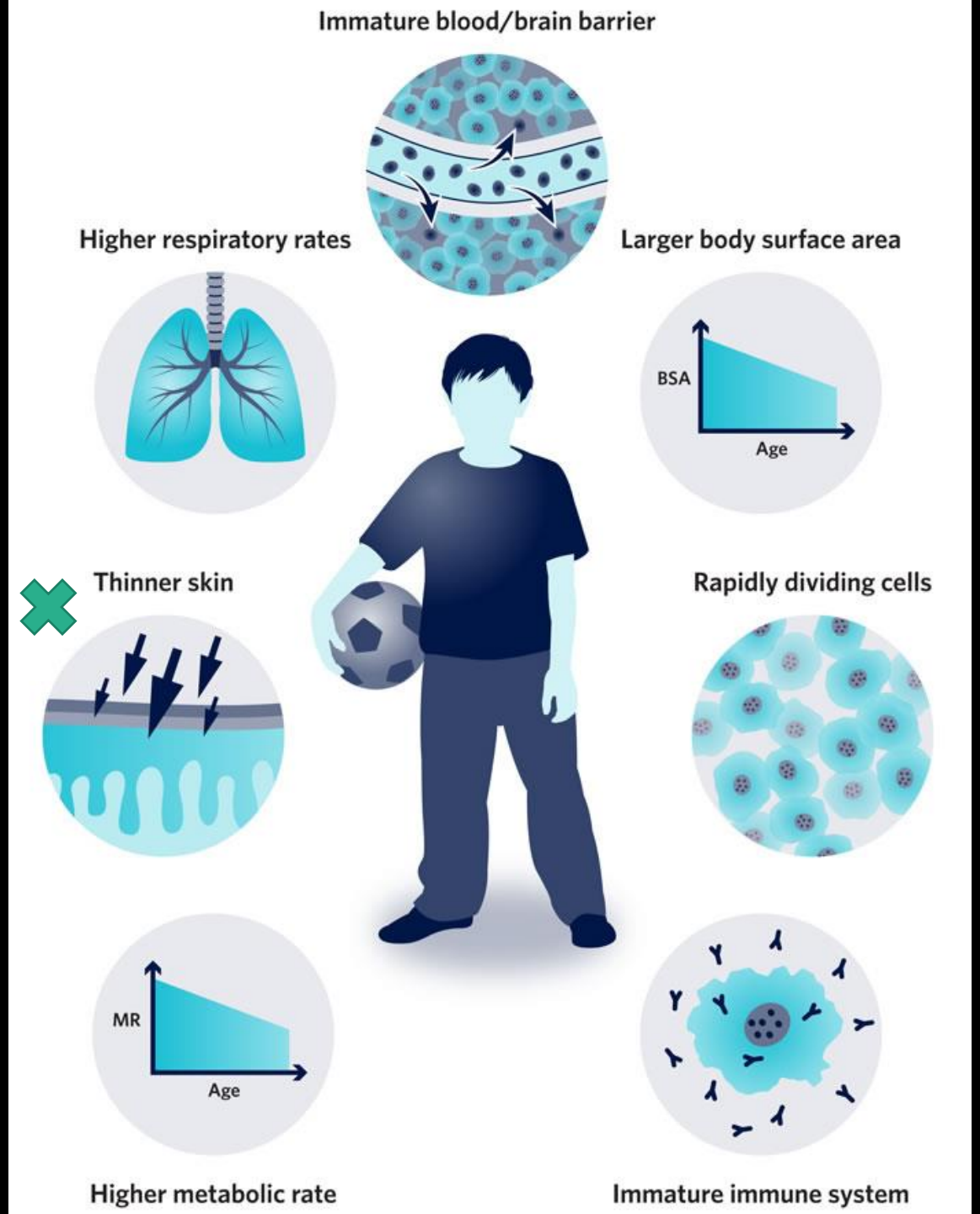
The smaller the patient, the greater the ratio of surface area (skin) to size

Higher risk of dehydration

http://www.emsworld.com

http://www.rch.org.au

Affected more quickly and easily by toxins absorbed through the skin

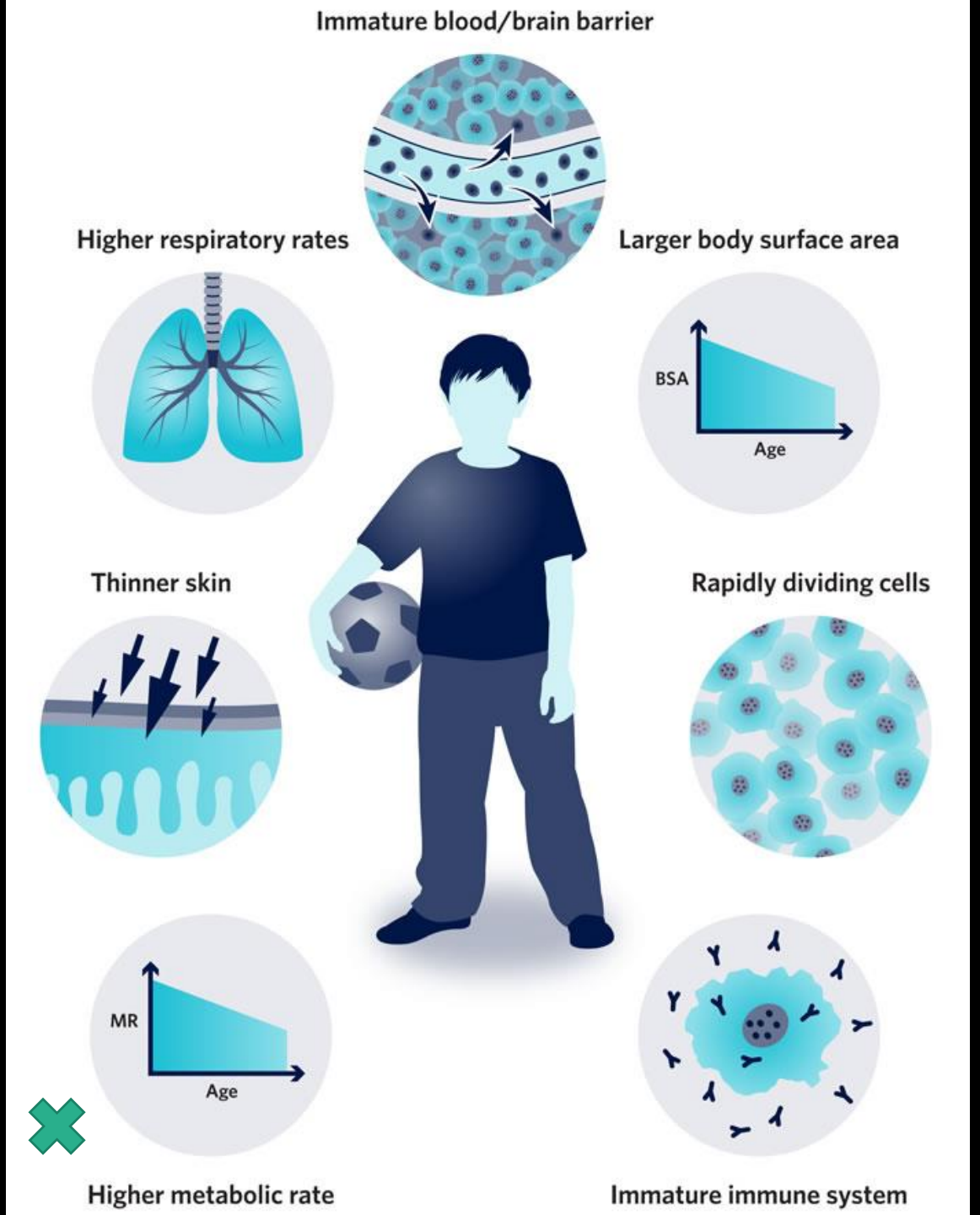


Epidermis is thinner and under-keratinized

http://www.emsworld.com

http://www.rch.org.au

Greater risk for increased loss of water and when ill or stressed



More susceptible to contaminants in food or water

Medication must be calculated based on weight

http://www.emsworld.com

http://www.rch.org.au

Adult heart increases its stroke volume by:

- strengthening contractions
- increasing heart rate

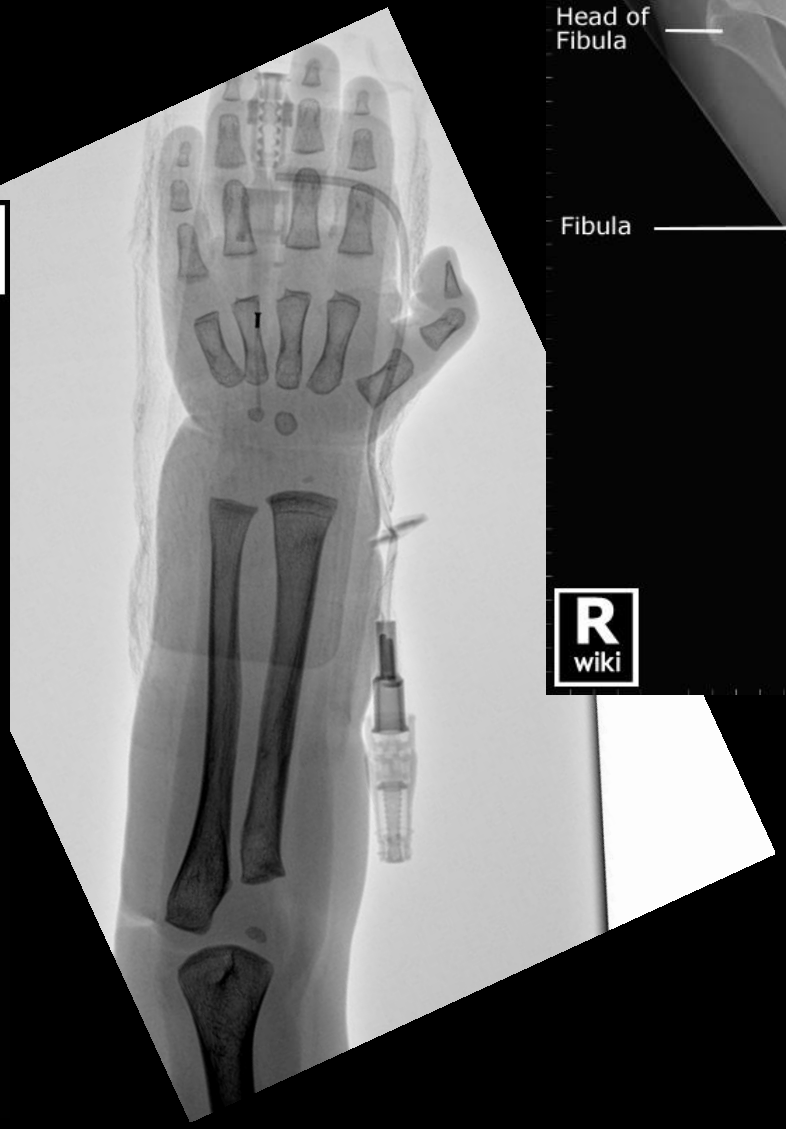
Pediatric heart can only increase heart rate

- occupies much of the thoracic cavity
- children have less pulmonary reserve than adults

10-year-old

2-month-old

- Bone are not completely calcified –more flexible.
- Ribs are more horizontal than they are rounded.



http://image.wikifoundry.com

http://www.emsworld.com

Because bone is not fully calcified the subject contrast in kids is lower

http://www.emsworld.com

http://image.wikifoundry.com

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Patient size measured on CT images as a function of age at a tertiary care children's hospital

TABLE 1: Age and Sex of Study Population

Age (y)[a]	Anatomic Region			
	Head	Thorax	Abdomen	Pelvis
< 1.0	47	17	16	15
1–2	17	12	10	9
2–3	12	17	12	15
3–4	14	17	18	14
4–5	12	16	14	16
5–6	16	13	15	17
6–7	14	8	9	11
7–8	11	14	16	16
8–9	17	15	11	12
9–10	14	21	15	14
10–11	15	16	15	13
11–12	15	17	17	19
12–13	16	16	22	19
13–14	18	16	24	24
14–15	20	16	19	26
15–16	18	17	25	18
16–17	17	21	21	19
17–18	15	23	19	22
18–19	15	20	16	17
19–20	7	11	14	11
20–21	6	13	8	9
Total	336	336	336	336
Sex ratio	M 195/F 141	M 181/F 155	M 188/F 148	M 177/F 159

[a]Statistically, each age group ranges from X–X.99 years.

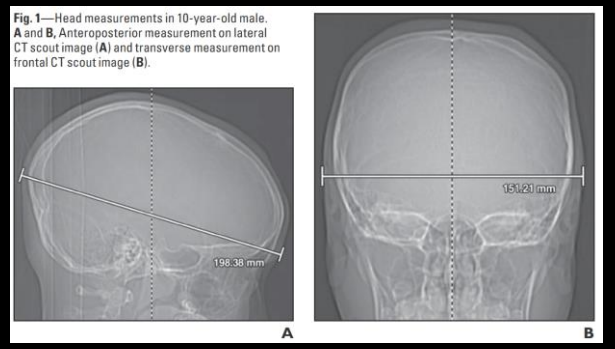


Fig. 1—Head measurements in 10-year-old male. A and B, Anteroposterior measurement on lateral CT scout image (A) and transverse measurement on frontal CT scout image (B).

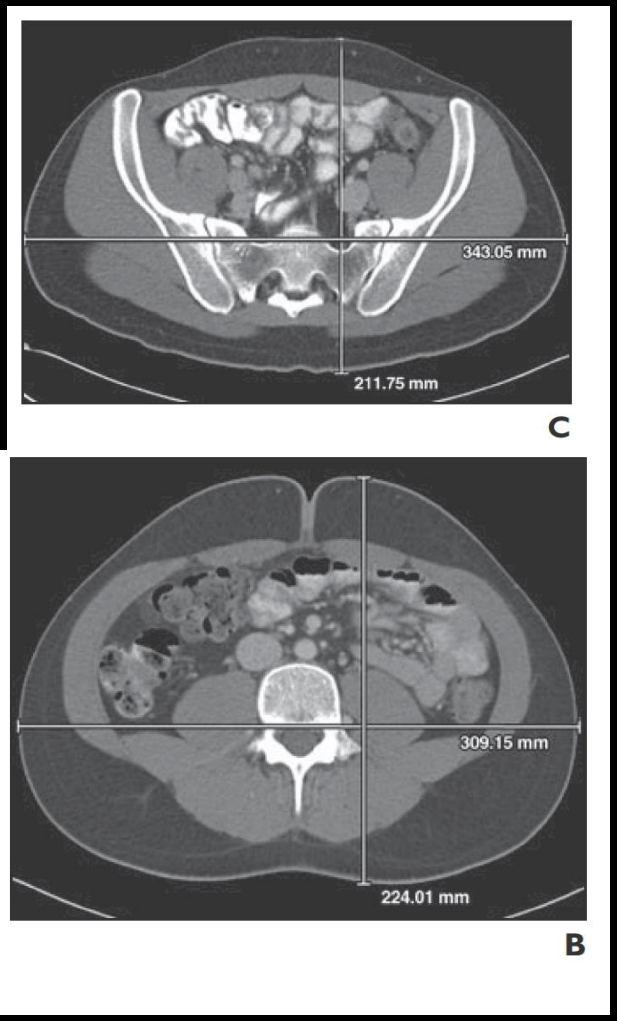
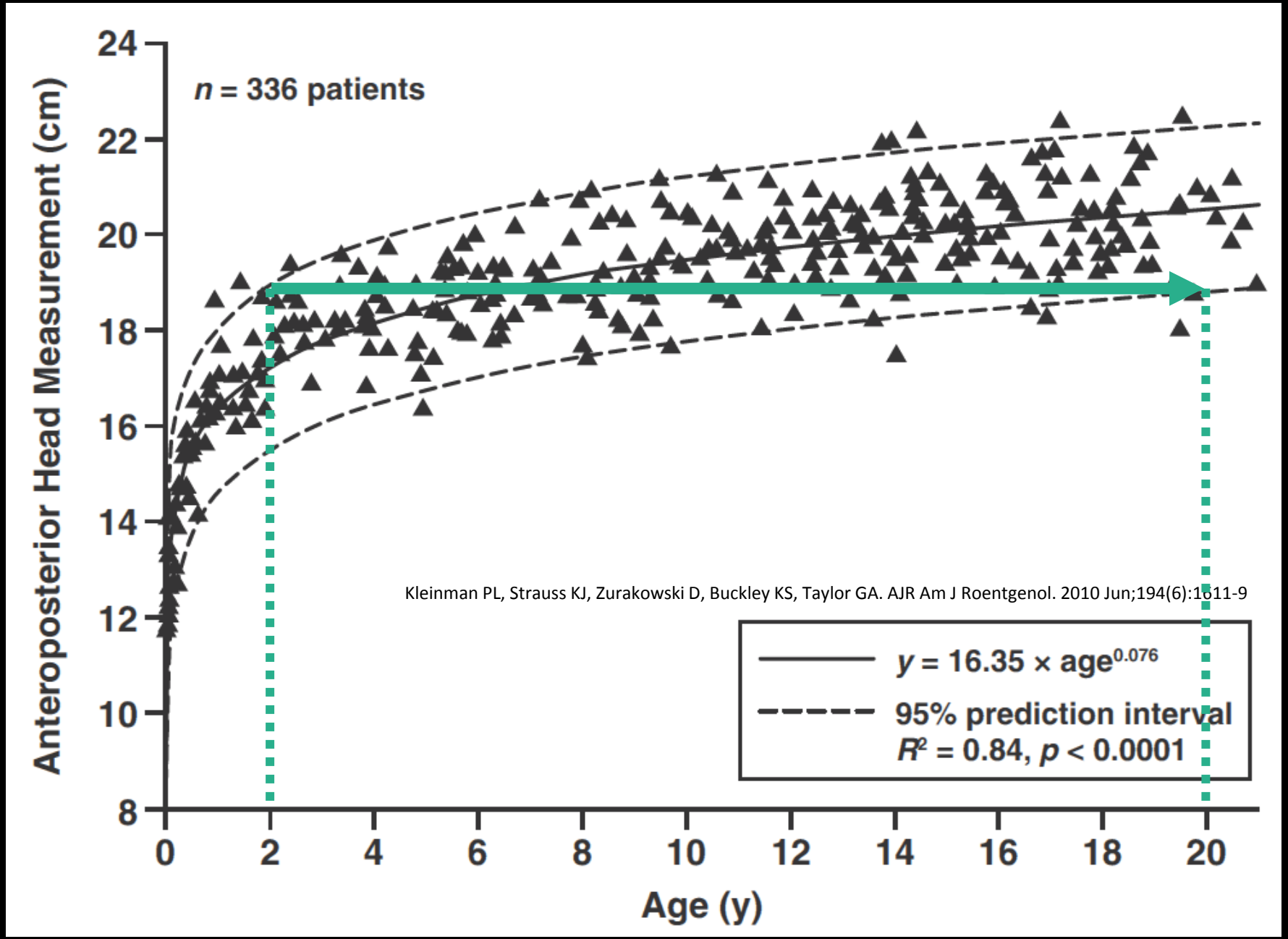


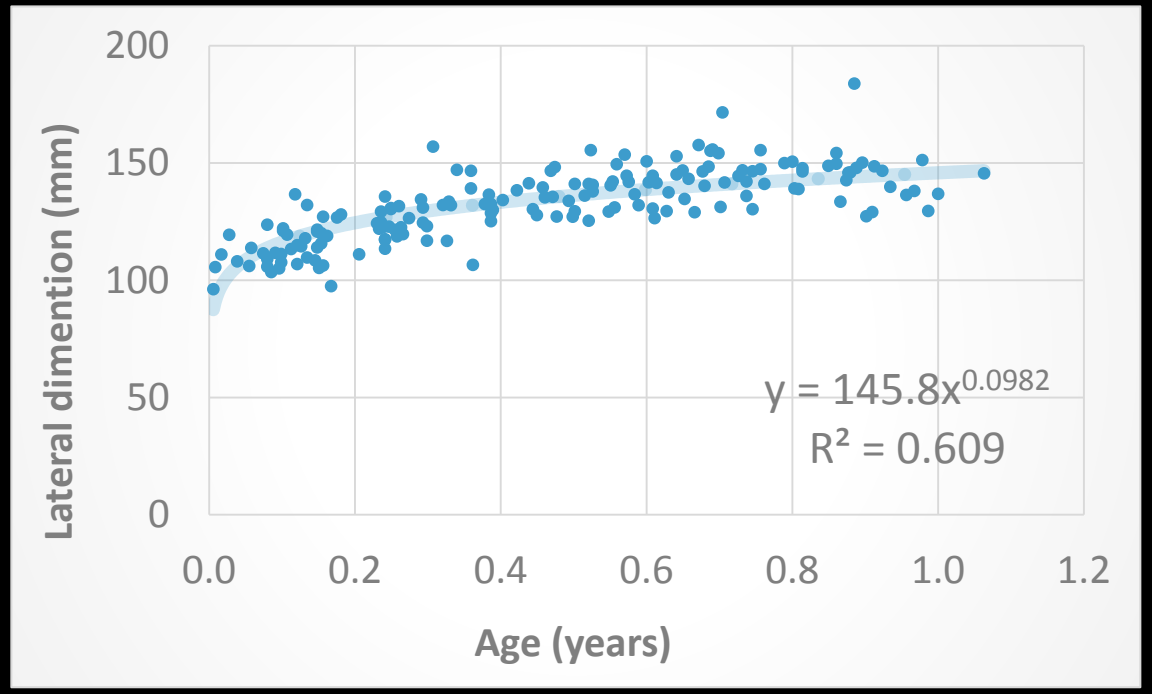
Fig. 2—Trunk measurements.

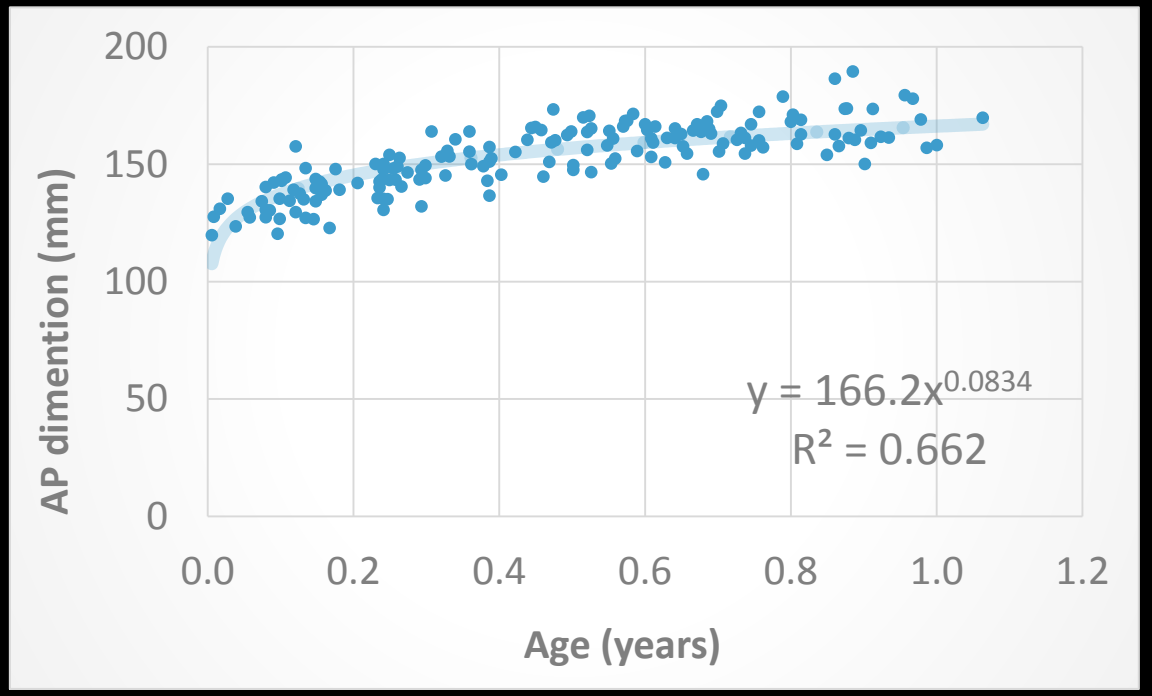
Kleinman PL, Strauss KJ, Zurakowski D, Buckley KS, Taylor GA. AJR Am J Roentgenol. 2010 Jun;194(6):1611-9.



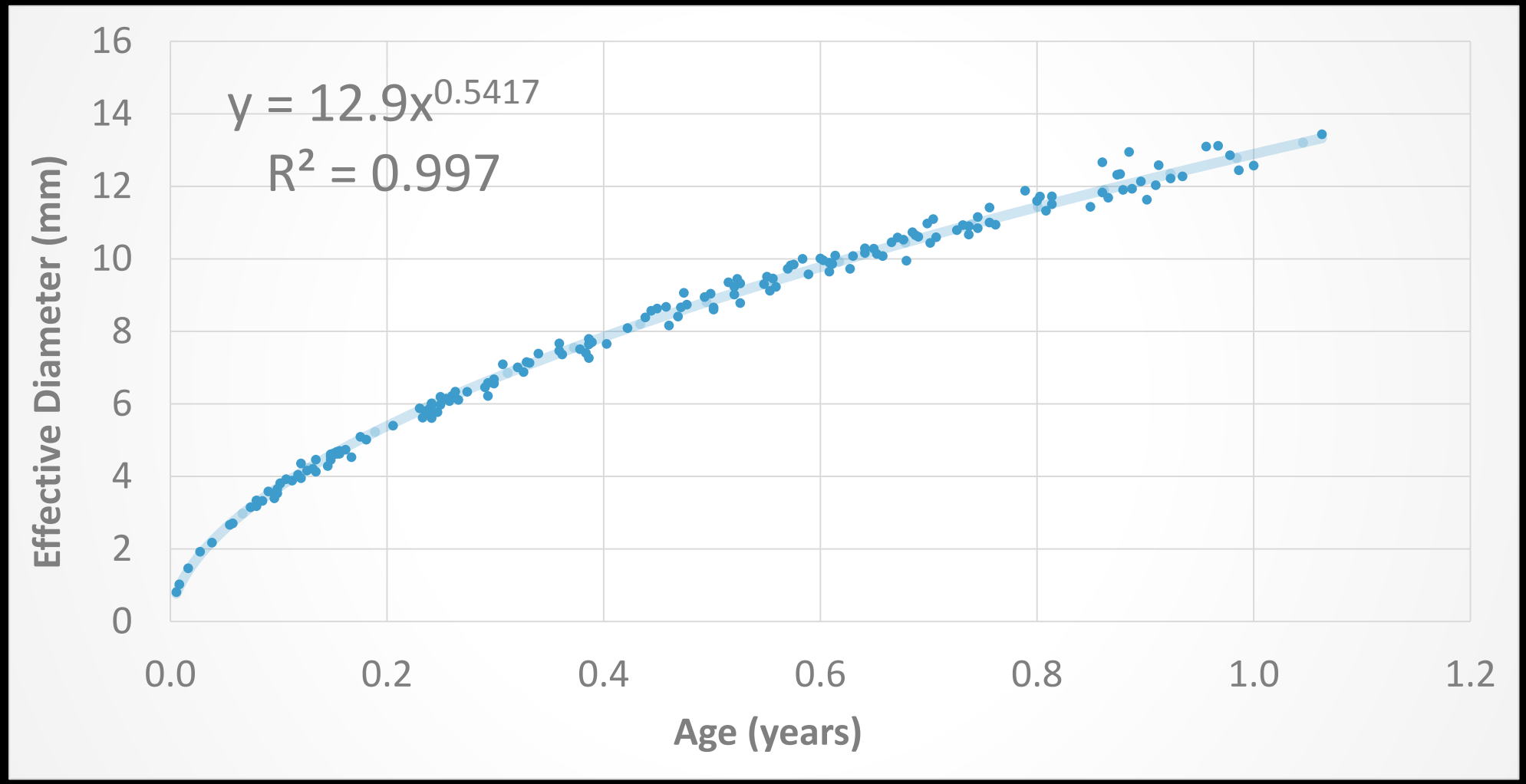
Kleinman PL, Strauss KJ, Zurakowski D, Buckley KS, Taylor GA. AJR Am J Roentgenol. 2010 Jun;194(6):1611-9

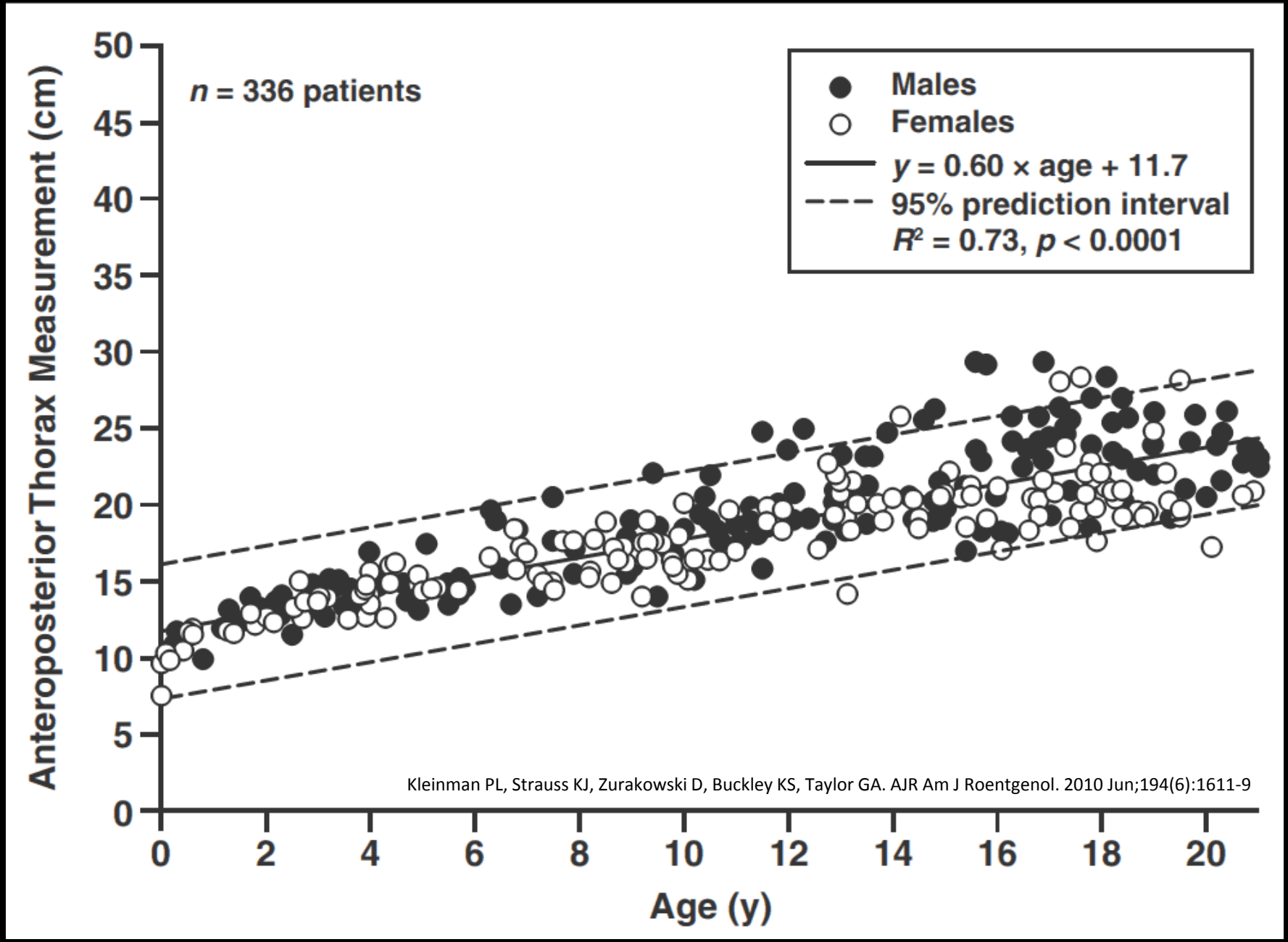
Age versus head size - TCH





Age versus head size – effective diameter





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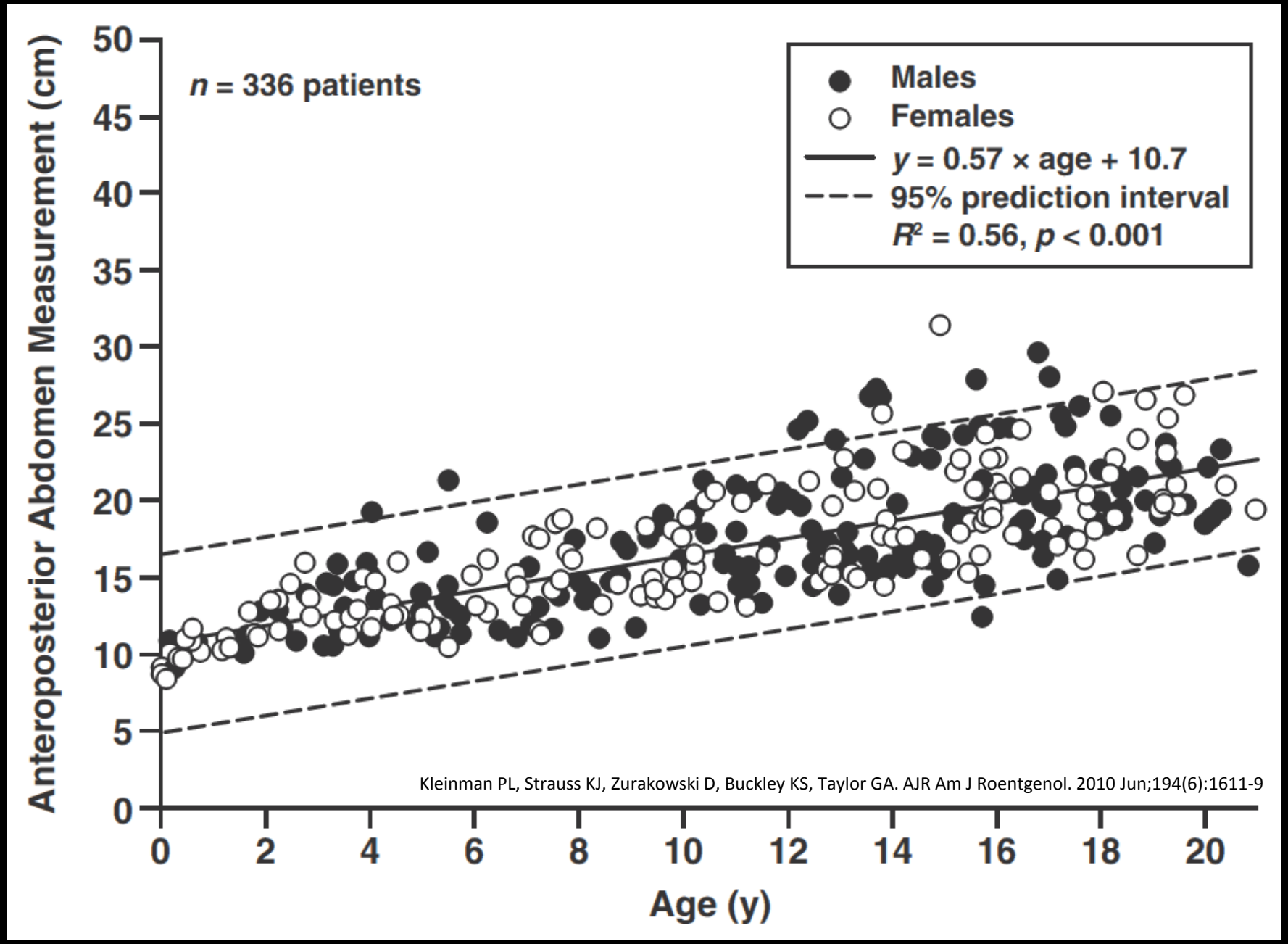

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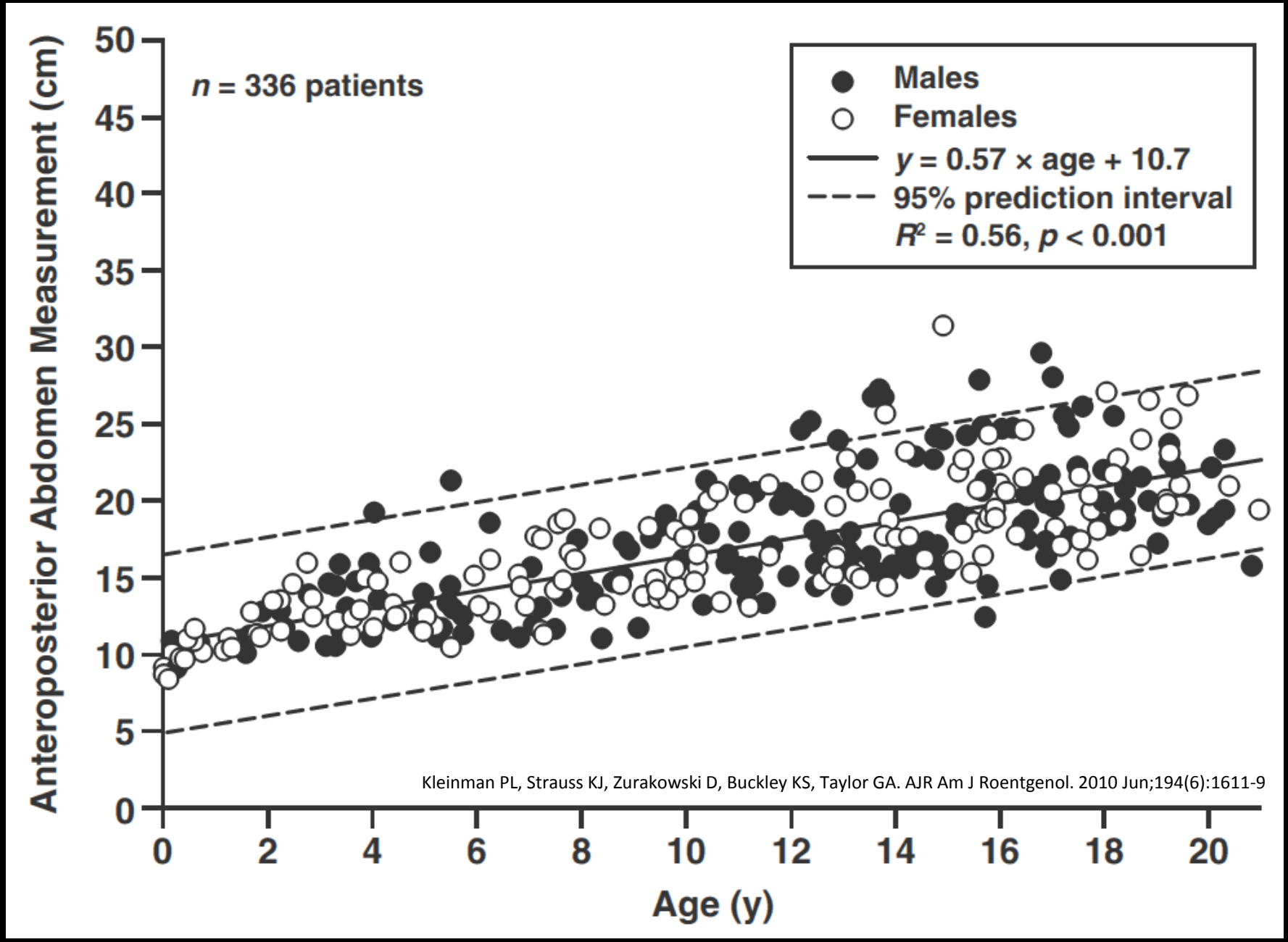

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Most common scan in TCH ER

	Neuro	Cases per month
N1	Trauma	208
N2	Headache	130
N3	VP shunt	94
N4	Infection	+
N5	Orbits infection/foreign body	9
N6	Neck/soft issue/ infection/tumor staging	31
N7	CTA brain	6
N8	CTV brain	2
N9	Neck CTA	2
N10	Neck CTV	-
N11	Sinuses	-
N12	Temporal bone	-
N13	Spine	-

	Body	Cases per month
B1	Pulmonary Mets	87
B2	Pulmonary Infection	45
B3	Staging mediastinal/lymphoma	22
B4	Pleural diseases	6
B5	HRCT (CF, bronchiectasis)	9
B6	Lung congential (CHD, CPAM)	12
B7	Pectus	6
B8	Lung Disease, Other	11

	Abdomen + Pelvis	Cases per month
A1	Tumor staging	46
A2	Infection fungal	11
A3	Renal stone	7
A4	Routine abdomen and pelvis	55
A5	Renal CTA	10
A6	Abdomen trauma	5
A7	Multiphase abdomen	2
A8	Abdomen CTA/CTV (liver, PV, WC)	13
A9	Abd, pelvis, other	-

Indications for head CT

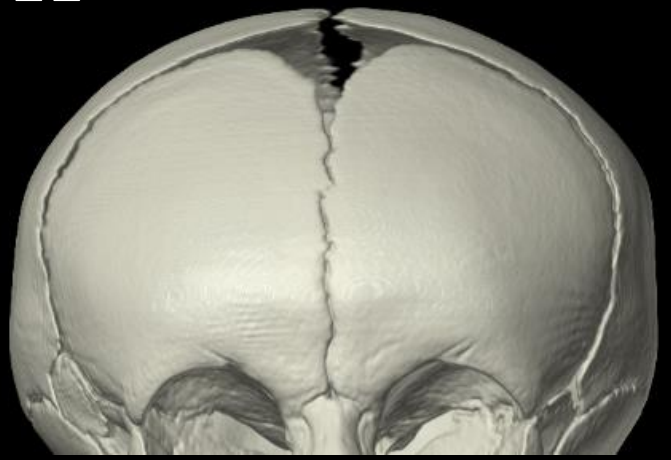
- Trauma
- Headache
- Dizziness and vomiting (intra-cranial pressure)

- MRI used to follow up findings or if the CT is negative and symptoms persist, then determine cause

1/31

2/15

3/11



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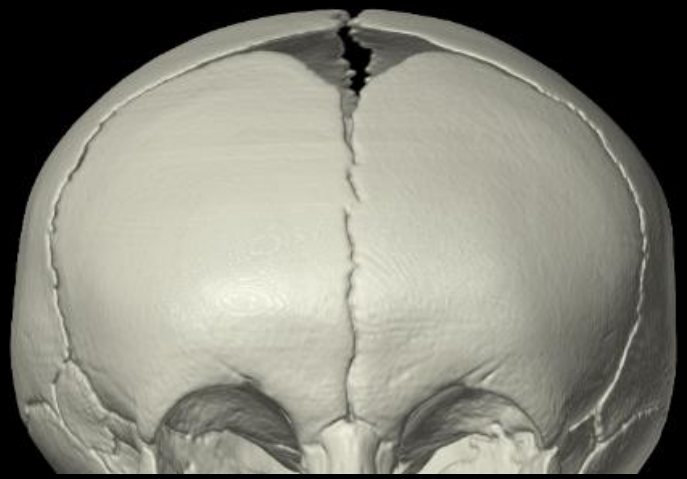

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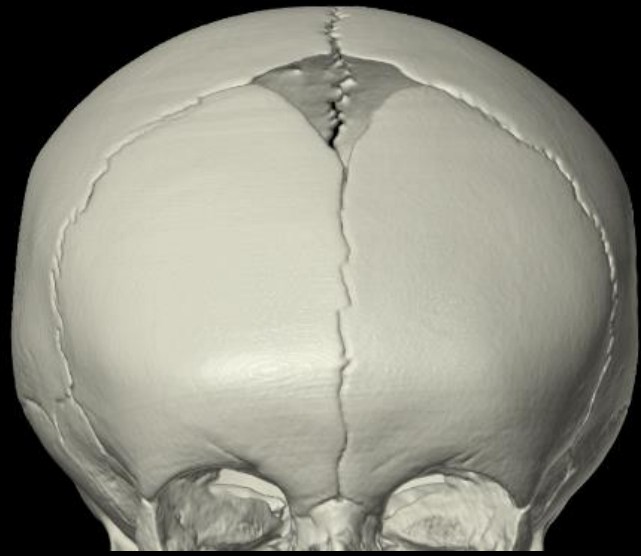
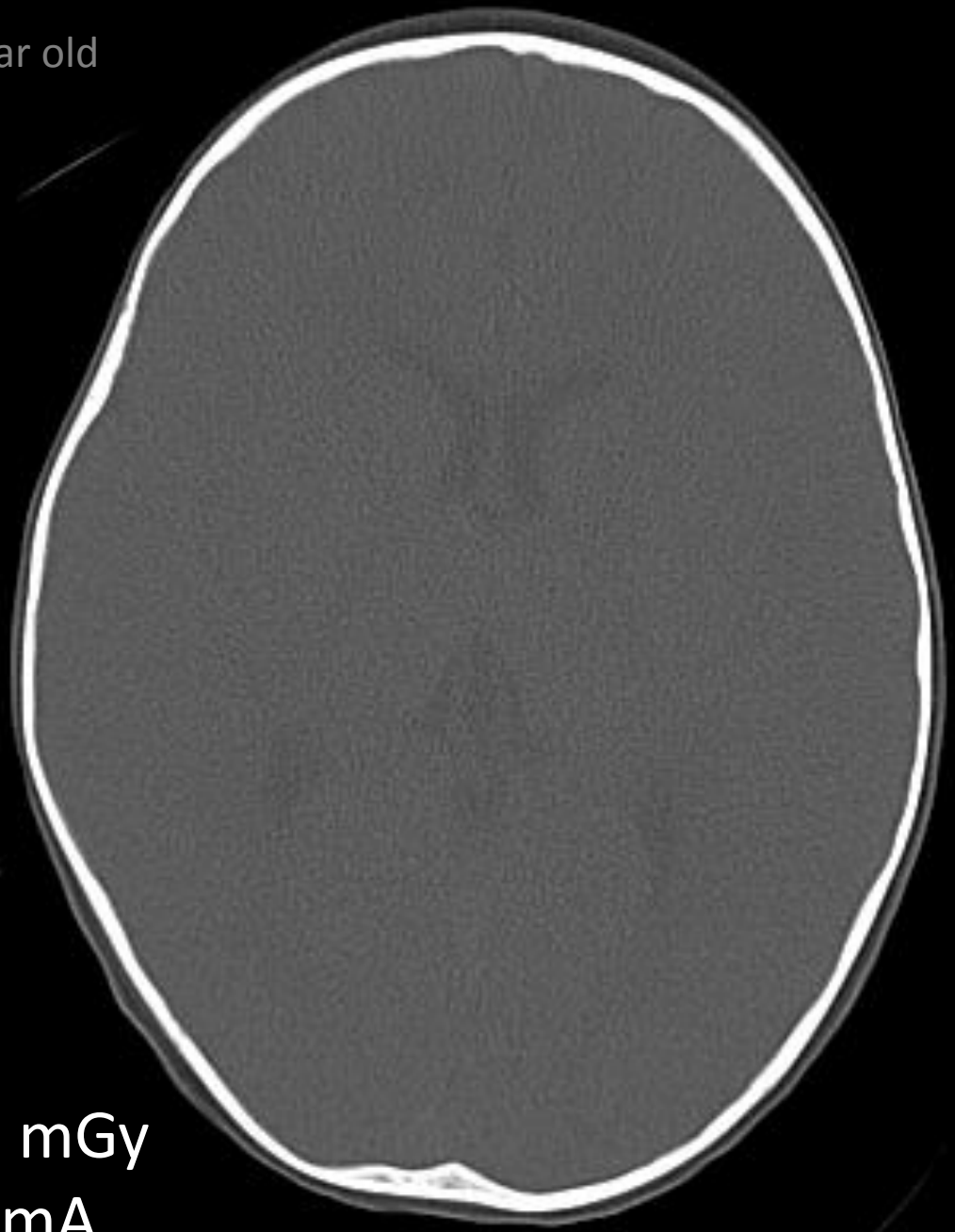


Indications for head CT

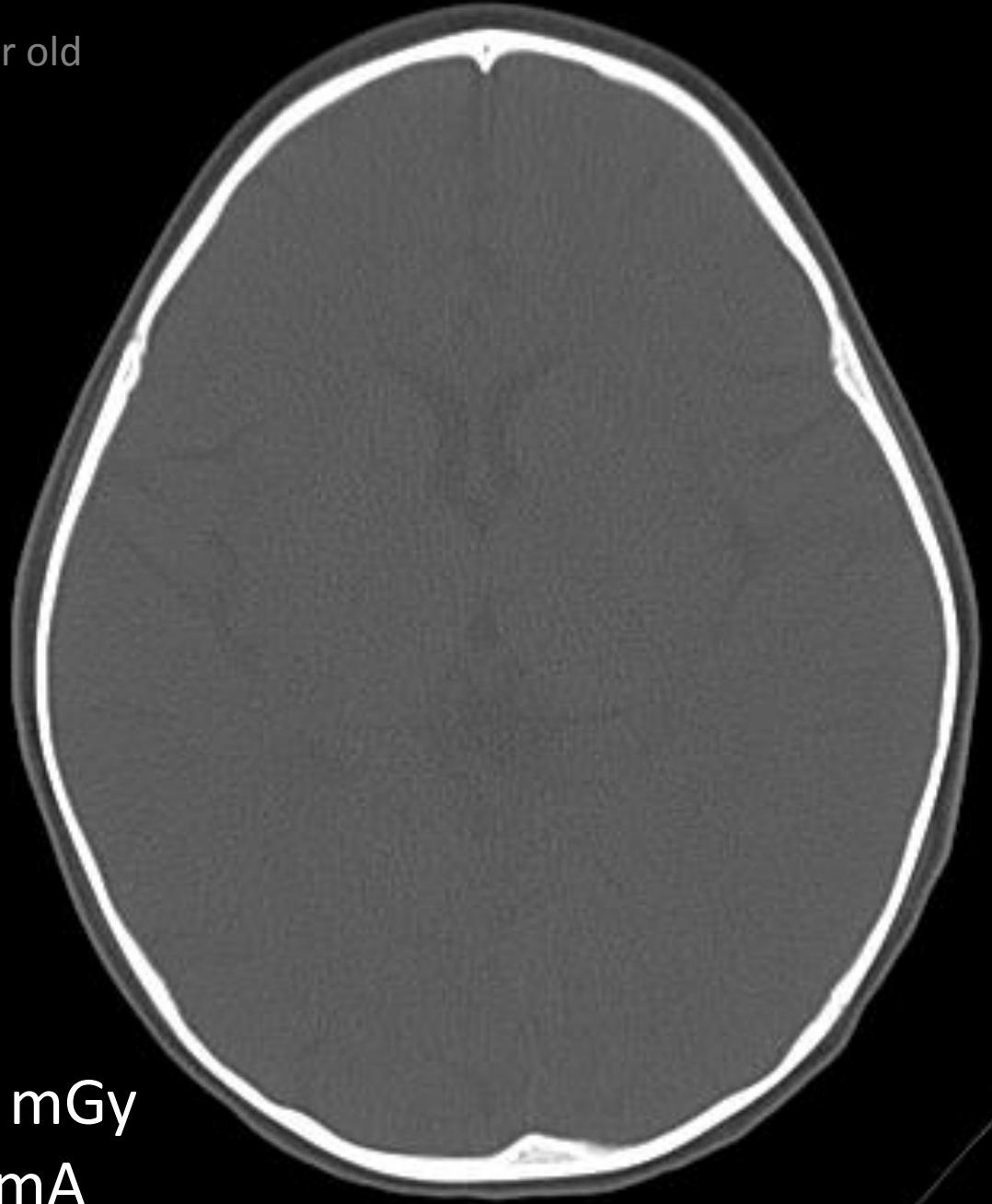
- Looking for gross anatomy:
  - Fractures
  - Masses
  - Bleeding in an and around the brain
- The types of diseases are different in kids
  - CT protocols are not developed to detect the same type of anatomy as in adults
  - Lung cancer is not prevalent in the pediatric population – CT scans are not optimized to detect small lung nodules

1.2 year old



21.3 mGy
250 mA

1.6 year old



34.5 mGy
350 mA

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TABLE 3: Technique for Head Studies; in this example, 120 kVp and 340 mAs with a pitch = 1 used for a standard adult *head* scan.

Head Baseline:	Head Baseline:	Head Baseline:	kVp	mA	Time (sec)	Pitch During Measured CTDIvol	Pitch During Clinical Exam	
			120	340	1.00	1.0	1.0	
AP Thickness (cm)	LAT Thickness (cm)	Effective Diameter (cm)	Mass (kg)	Age	*Limited* mAs Reduction Factor	*Moderate* mAs Reduction Factor	Limited Estimated mAs	Moderate Estimated mAs
14	12	13	4	newborn	0.74	0.38	252	129
16	13	14.5	10	1 yr	0.80	0.47	272	160
17	14	15.5	13	2 yr	0.86	0.62	292	211
19	15	17	21	6 yr	0.93	0.79	316	269
20	16	18	75	md adult	1	1	340	340

Establish **acceptable scan parameters**, CTDIvol and Size Specific Dose Estimate (SSDE) for adult size patients on department's primary CT scanner.

Match image quality of all CT scanners in department to department's primary CT scanner.

Establish pediatric patient abdominal and abdominal/pelvic **Diagnostic Reference Levels (DRLs)** and scan parameters for all CT scanners in department.

Establish **pediatric patient thorax** DRLs for all CT scanners in department.

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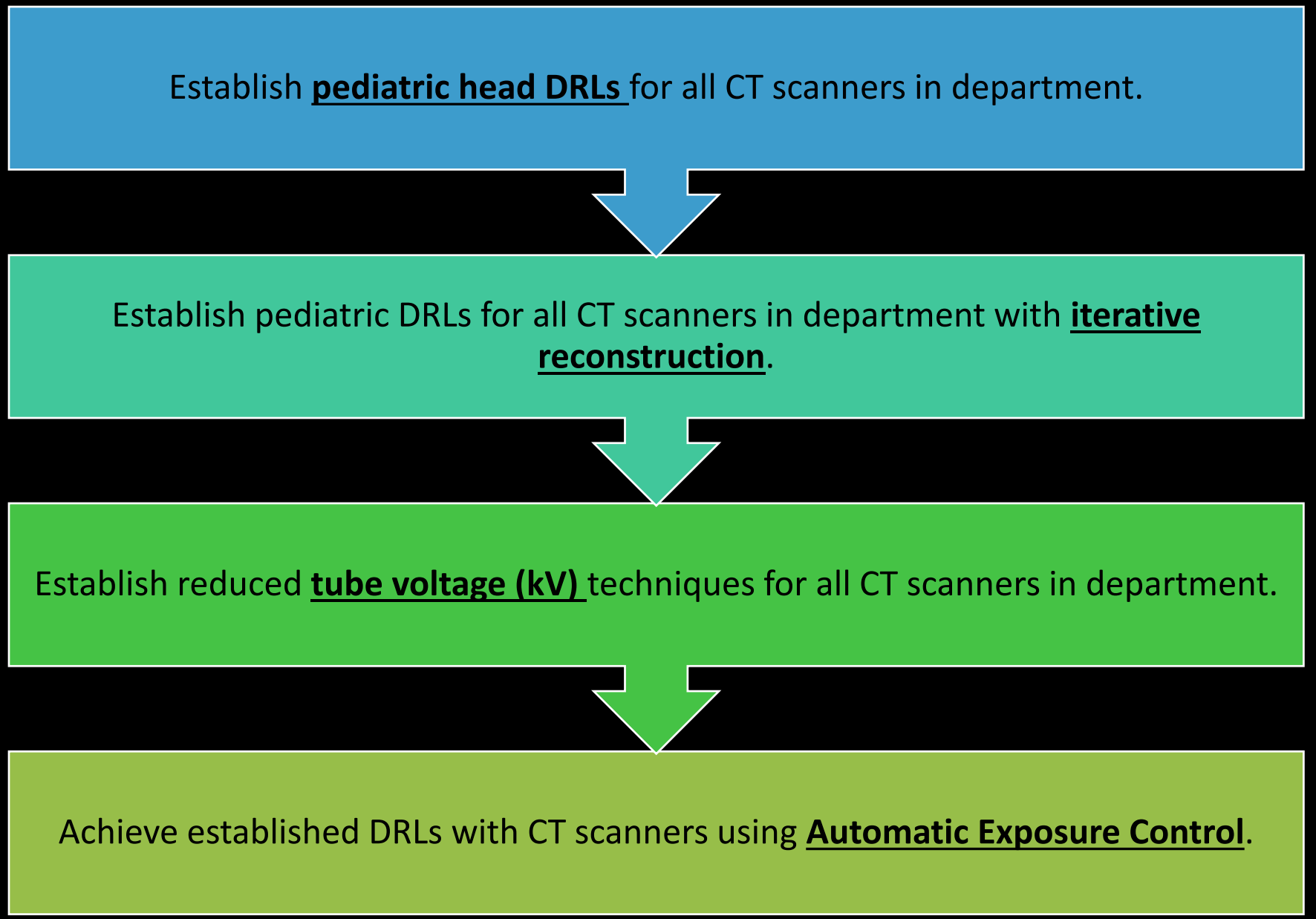

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Step 1: Define the optimal protocol

Establish acceptable scan parameters, $CTDI_{vol}$ and Size Specific Dose Estimate (SSDE) for adult size patients on department's primary CT scanner.

- Calculate $CTDI_{vol}$ and SSDE for the baseline scans that you have
- Compare those numbers to ACR or other sources or DRLs
- Talk to your radiologists to ensure that the images are adequate and not too noisy

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Goske *et al*. Diagnostic reference ranges for pediatric abdominal CT. Radiology. 2013 Jul;268(1):208-18.

The diagnostic reference range (DRR) is a newer quality improvement tool that provides a minimum estimated patient radiation dose, below which reduced image quality may not be diagnostic, and an upper estimated patient dose, above which the dose may be in excess.

For 954 scans, DRRs (SSDEs) were 5.8–12.0, 7.3–12.2, 7.6–13.4, 9.8–16.4, and 13.1–19.0 mGy for BWs less than 15, 15–19, 20–24, 25–29, and 30 cm or greater, respectively. The fractions of adult doses, adult SSDEs, used within the consortium for patients with BWs of 10, 14, 18, 22, 26, and 30 cm were 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9, respectively.

DRRs based on 969 Abd/Pel patients

- 98% single phase
- 28% without TCM
- Pain was the most common indication (49%), then trauma (17%), tumor (9%)

Table 3

Distribution of SSDE

BW Group	No. of Scans	Mean	Standard Error	Lower DRR, 25th Percentile	Median, 50th Percentile	Upper DRR, 75th Percentile	$SSDE/SSDE_{adult}$ Ratio
<15 cm	21	8.6	0.9	5.8	8.0	12.0	0.52
15–19 cm	153	10.0	0.5	7.3	8.7	12.2	0.61
20–24 cm	286	11.4	0.7	7.6	9.8	13.4	0.69
25–29 cm	326	13.5	0.3	9.8	13.0	16.4	0.82
⩾30 cm	168	16.5	0.4	13.1	15.6	19.0	1.00

Goske et al. Diagnostic reference ranges for pediatric abdominal CT. Radiology. 2013 Jul;268(1):208-18. doi: 10.1148/radiol.13120730. Epub 2013 Mar 19.

Step 2: Uniformity across the enterprise

Match image quality of all CT scanners in department to department's primary CT scanner.

- Match radiation dose (not protocol parameters such as mAs) across all scanners at the institution
- Monitor the changes to ensure clinical image quality is acceptable

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Steps to establish pediatric size-specific protocols

1. Establish acceptable scan parameters, CTDIvol and Size Specific Dose Estimate (SSDE) for adult size patients on department's primary CT scanner.
2. Match image quality of all CT scanners in department to department's primary CT scanner.
3. Establish pediatric patient abdominal and abdominal/pelvic Diagnostic Reference Levels (DRLs) and scan parameters for all CT scanners in department.
4. Establish pediatric patient thorax DRLs for all CT scanners in department.
5. Establish pediatric head DRLs for all CT scanners in department.
6. Establish pediatric DRLs for all CT scanners in department with iterative reconstruction.
7. Establish reduced tube voltage (kV) techniques for all CT scanners in department.
8. Achieve established DRLs with CT scanners using Automatic Exposure Control (AEC).

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Abdomen/	Abdomen/	Abdomen/	kVp	mA	Time (sec)	Pitch During Measured CTDIvol	Pitch During Clinical Exam	Adult SSDE					
Pelvis:	Pelvis:	Pelvis:	120	160	1	1	1	18					
AP Thickness (cm)	LAT Thickness (cm)	Effective Diameter (cm)	Mass (kg)	Age	*Limited* mAs Reduction Factor (1)	*Moderate* mAs Reduction Factor(0.75)	*Aggressive* mAs Reduction Factor(0.5)	*Limited* mAs SSDE	*Moderate* mAs SSDE (mGy)	*Aggres-sive* mAs SSDE	*Limited* NB = Adult SSDE Estimated mAs	*Moderate* NB = 0.75 * Adult SSDE Estimated mAs	*Aggressive* NB = 0.5 * Adult SSDE Estimated mAs
10	14	11.8	4	newborn	0.52	0.39	0.25	18	13	9	83	62	40
11	16	13.3	10	1 yr	0.55	0.42	0.29	18	14	10	88	67	47
14	20	16.7	18	5 yr	0.62	0.50	0.39	18	15	12	99	80	62
16	25	20.0	33	10 yr	0.70	0.62	0.53	18	16	14	112	99	85
19	29	23.5	54	15 yr	0.80	0.74	0.68	18	17	16	128	119	109
22	32	26.5	65	20 yr	0.89	0.86	0.83	18	17	17	143	138	132
25	35	29.6	75	md adult	1.00	1.00	1.00	18	18	18	160	160	160
31	41	35.7	110	lg adult	1.21	1.28	1.35	18	19	21	194	205	216

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A few guidelines

1. Thorax versus abdomen techniques should be lowered by ~20% to account for the presence of air
2. A 5-year-old head is about 90% of the adult head size
3. A 1 year old's head CT scan dose should be about ½ of the adult dose
4. Using iterative reconstruction can reduce the dose by 30%
5. Lowering kVp:
    1. Less energy of the photons – less penetration
    2. Increase noise in the image
    3. Used to increase subject contrast – can increase mAs to keep the dose and noise the same as for the higher kVP

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Available Protocols

www.aapm.org/pubs/CTProtocols

Adult Protocols

- Lung Cancer Screening CT (updated 02/23/2016) [Give Feedback]
- Routine Adult Chest-Abdomen-Pelvis CT (added 02/20/2014) [Give Feedback]
- Routine Adult Chest CT (updated 05/04/2016) [Give Feedback]
- Routine Adult Abdomen/Pelvis CT (updated 08/07/2015) [Give Feedback]
- Routine Adult Head CT (updated 03/01/2016) [Give Feedback]
- Routine Adult Brain Perfusion (updated 03/01/2016) [Give Feedback]

Pediatric Protocols

- Routine Pediatric Head CT (updated 12/14/2015) [Give Feedback]

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AXIAL SCANS	CHARACTERISTICS	HELICAL SCANS
Longer	Acquisition Time	Shorter
Less artifacts in some cases, especially for < 16 detector row scanners – motion artifacts more likely due to longer scan times	Artifacts	More artifacts for < 16 detector row scanners; close to or equivalent to axial for ≥ 64 detector row scanners – motion artifacts less likely due to shorter scan times, and therefore less need for repeats
Better in some cases, especially for < 16 detector row scanners	Image Quality	Equivalent in most cases; close to or equivalent to axial for ≥ 64 detector row scanners
Depends more on protocol than on axial or helical mode of acquisition	Radiation Dose	Depends more on protocol than on axial or helical mode of acquisition
Present in both helical and axial scans	Over Beaming (x-ray beam extending beyond the edge of active detector rows)	Present in both helical and axial scans
None or very little over ranging (limited to that caused by over beaming)	Over Ranging (irradiation of tissue inferior and superior to desired scan range)	Helical scans all have over ranging[2]. Some scanners have features that minimize this. Scan range may extend to thyroid and/or orbit regions.
Detector configuration is often narrower than for body scans	Detector Configuration (N x T mm)	Detector configuration is often narrower than for body scans
Gantry can be tilted	Gantry Tilt	Gantry cannot be tilted on some scanners
Limited to thicknesses allowed by detector configuration	Image Thickness	Limited to thicknesses allowed by detector configuration
Limited to only a few commercial CT systems	Multiplanar Reformation Capability	Coronal and sagittal reformations possible on nearly every CT system with 16 or more detector rows

PEDIATRIC HEAD – ROUTINE (AXIAL) (selected GE scanners)

(Back to INDEX)

SCOUT: Lateral, 120 kVp, 40 mA, from base of skull through vertex, angle to Reid's baseline to avoid orbits

GE	LightSpeed 16 BrightSpeed 16	LightSpeed Pro 16	Optima CT660	Optima CT660 w/ASiR
Scan Type	AXIAL	AXIAL	AXIAL	AXIAL
Rotation Time (s)	1*	1*	1*	1*
Detector Configuration	16 x 0.625 (10mm, 8i)	16 x 0.625 (10mm, 8i)	32 x0.625 (20mm, 8i)	32 x0.625 (20mm, 8i)
Table Feed/Interval (mm)	10	10	20	20
kV	120	120	120	120
Manual mA approach	0-1yr: 110 1-2yrs: 130 2-6yrs: 170 6-16yrs: 220 16+yrs: 280	0-1yr: 110 1-2yrs: 130 2-6yrs: 170 6-16yrs: 220 16+yrs: 280	0-1yr: 150 1-2yrs: 190 2-6yrs: 250 6-16yrs: 315 16+yrs: 400	0-1yr: 100 1-2yrs: 125 2-6yrs: 165 6-16yrs: 210 16+yrs: 265
Auto-mA approach	Not recommended	Not recommended	Not recommended	Not recommended
SFOV	HEAD	HEAD	HEAD	HEAD
ASiR	no	no	no	SS30
CTDI-vol (mGy)	0-1yr: 21.8 1-2yrs: 27.0 2-6yrs: 36.4 6-16yrs: 45.7 16+yrs: 58.2	0-1yr: 23.6 1-2yrs: 29.2 2-6yrs: 39.3 6-16yrs: 49.3 16+yrs: 62.8	0-1yr: 26.8 1-2yrs: 34.0 2-6yrs: 44.7 6-16yrs: 56.3 16+yrs: 71.6	0-1yr: 17.9 1-2yrs: 22.4 2-6yrs: 29.5 6-16yrs: 37.6 16+yrs: 47.4
Recon 1				
Plane	Axial	Axial	Axial	Axial
Algorithm	Stnd	Stnd	Stnd	Stnd
Recon Mode	Full	Full	Full	Full
ASiR	None	None	None	SS40
Thickness (mm)	5	5	5	5
Interval (mm)	5	5	5	5
Recon 2				
Plane	Axial	Axial	Axial	Axial
Algorithm	Bone	Bone	Bone	Bone
Recon Mode	Full	Full	Full	Full
ASiR	None	None	None	SS30
Thickness (mm)	5	5	5	5
Interval (mm)	5	5	5	5

* Shorter rotation times should be considered if the required tube current-time product (mAs) can be reached.

From a fellow physicist….

- Work with one (head) radiologist
- Get insights on what features are relevant in that protocol
- Work with a good technologist
  - preferred recon views
  - contrast injection rate

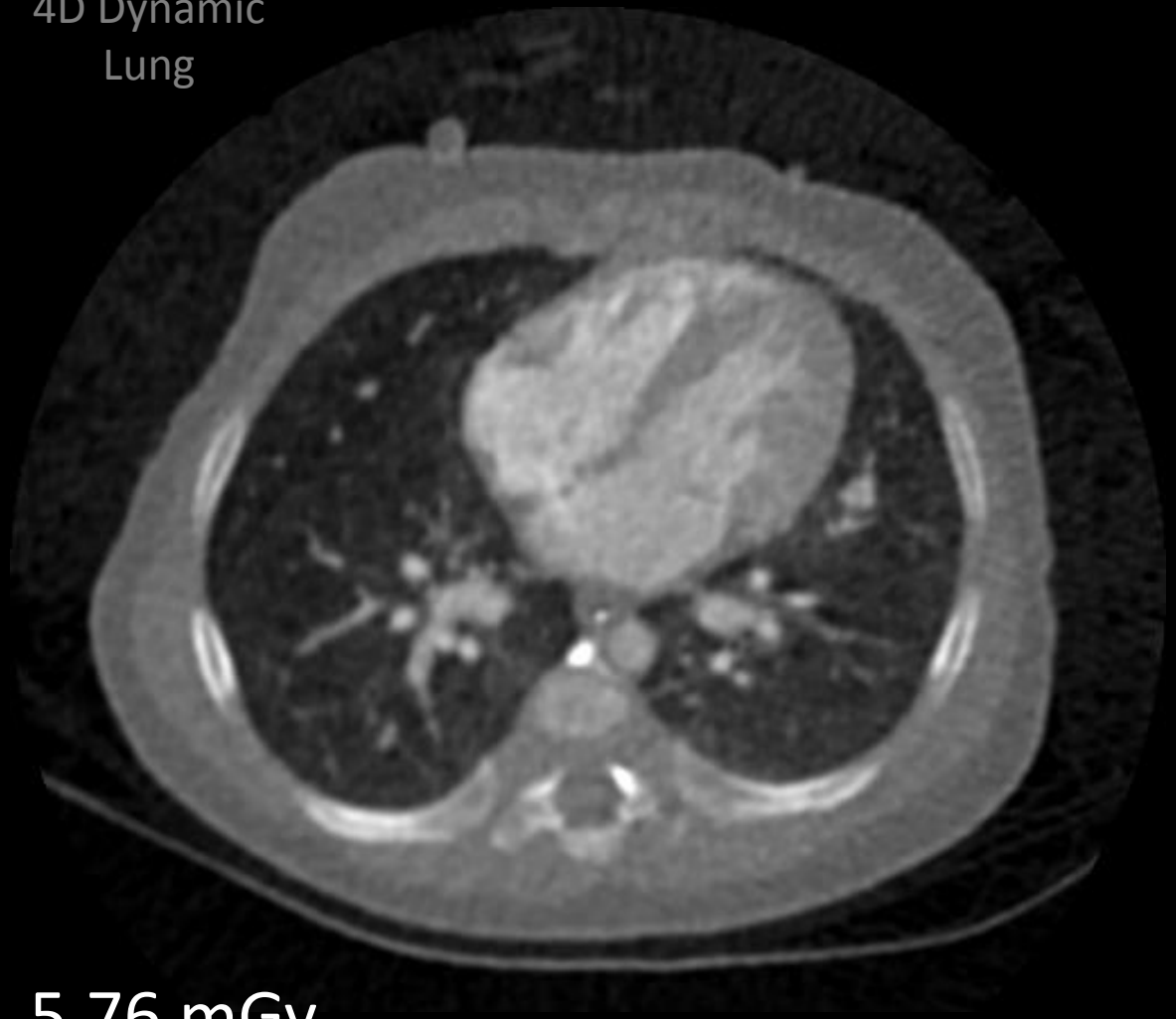
From a fellow physicist….

- A radiologist will not agree with a physicist’s idea of the best image acquired with the lowest dose possible
- Different units of the same manufacturer and model can behave differently
  - change focal spot at different mA stations

From the radiologists…

- Pediatric scans are noisier
  - Pediatric brain isn’t completely myelinated yet
  - Difficult to tell the difference between a pixel and a punctate bleed or calcification
  - Need to look at the noise pattern and decide if it’s real or not
  - Less confident in subtle changes

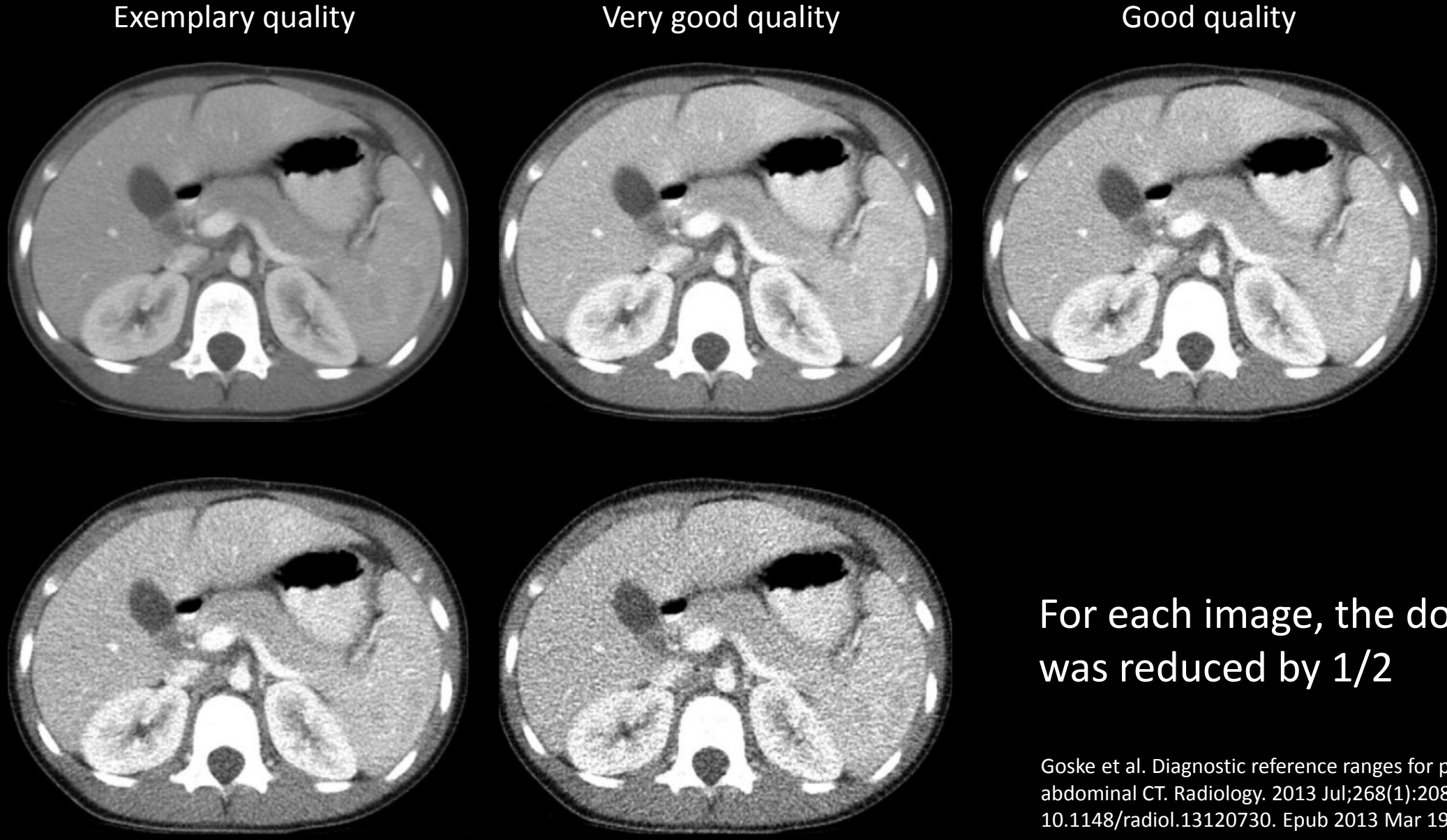
4 month old
4D Dynamic
Lung



5.76 mGy
80 kVp, 10.5 mAs

2 year old
4D Dynamic
Lung

8.1 mGy
80 kVp, 15 mAs



For each image, the dose was reduced by 1/2

Goske et al. Diagnostic reference ranges for pediatric abdominal CT. Radiology. 2013 Jul;268(1):208-18. doi: 10.1148/radiol.13120730. Epub 2013 Mar 19.

From the radiologists…

- Use iterative reconstruction algorithms to smooth out images
- Co-operation in kids is often a major hurdle
- Smaller organs and smaller features
  - Difficult to visualize pediatric bile ducts

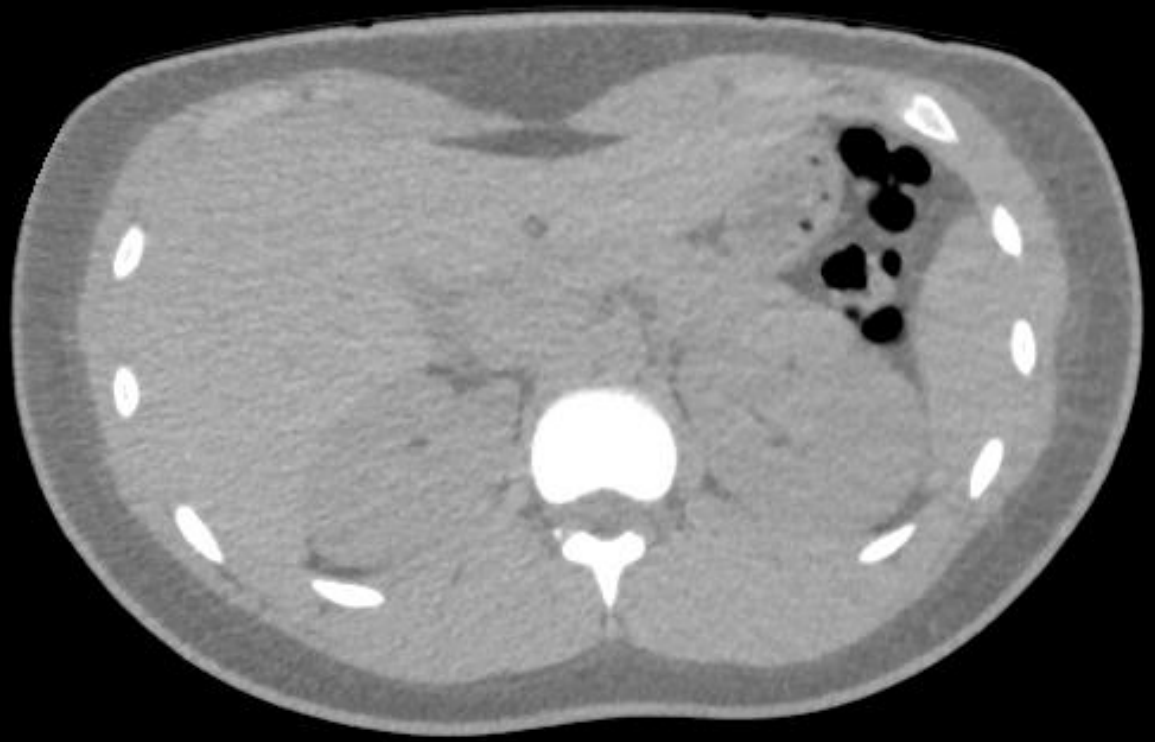
Final thought…

- Indication-based CT protocols are the key to optimize dose and image quality in the pediatric population
- Historically, the indication for stroke (ischemic process) is one of the reasons to keep dose high in head CT but…

even if it is detected, there is no treatment

– will not impact patient care

17 year old
Renal stone



7 mGy
SD 18

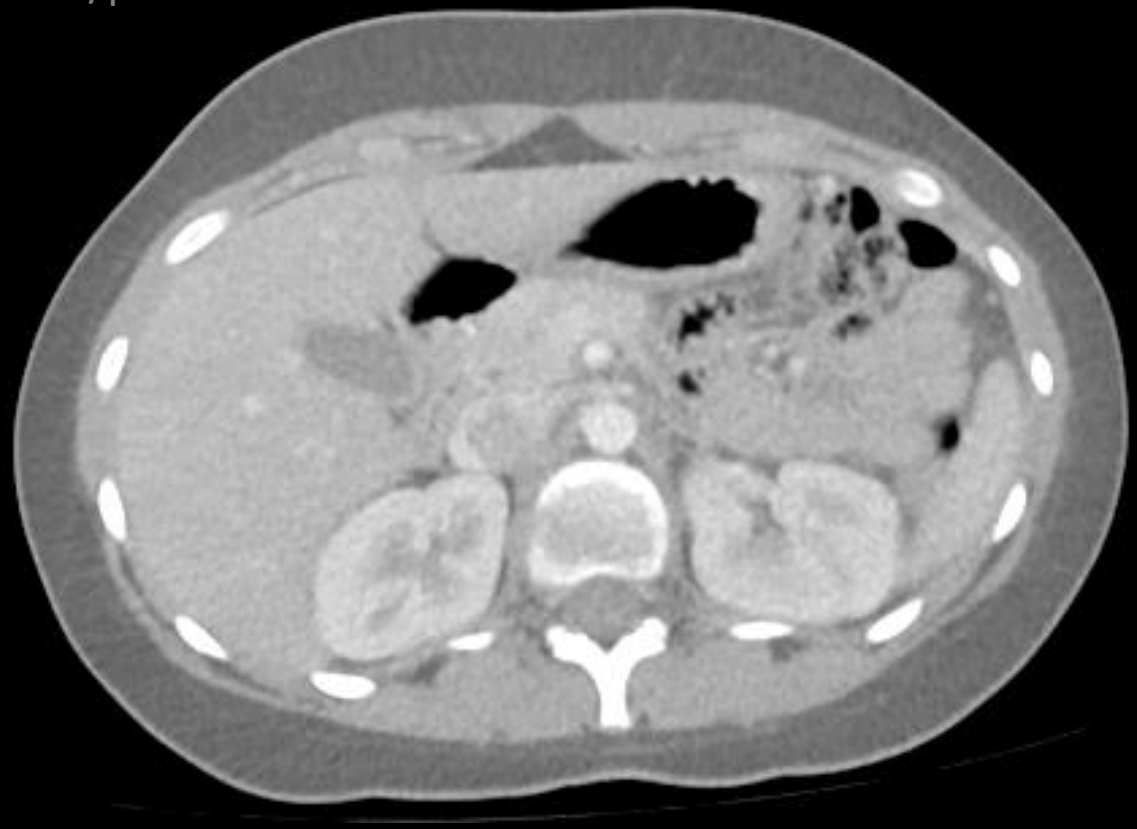
11 year old
Appendicitis

15.9 mGy
SD 8

16 year old
Routine
Abd/pel

10.2 mGy
SD 12.5

16 year old
Trauma
Abd/pel



5.3 mGy
SD 8

Outline

- How is the pediatric patient different?
- Pediatric patient age and size
- The most common CT scan in the ER
- Step-by-step approach to optimizing pediatric protocols
- Notes for the medical physicist
- Notes for the technologists

TCH Adult Protocols

Fixed mAs

- Routine Brain
- Sinuses
- Max-face and orbits
- Brain perfusion
- Stroke
- Brain CTA
- Brain shunt
- Mastoids
- 4D dynamic lung
- Chest biopsy
- Extremity: foot, hip, knee, ankle, shoulder, hand, wrist, elbow

TCM

- Neck
- C-spine
- Chest
- CTA/PE heart
- T-spine
- L-spine
- Chest/Abdomen/Pelvis (trauma, tumor)
- Liver
- Renal stone
- Appendicitis
- Pancreas
- Kidneys

TCH Pedi Protocols

Fixed mAs

- Routine Brain
- Sinuses
- Max-face and orbits
- Brain perfusion
- Stroke
- Brain CTA
- Brain shunt
- Mastoids
- 4D dynamic lung
- Chest biopsy
- Extremity: foot, hip, knee, ankle, shoulder, hand, wrist, elbow
- **C-spine, Chest, CTA/PE heart < 30 kg**
- **NICU abdomen**

TCM

- Neck
- **C-spine > 30 kg**
- **Chest > 30 kg**
- **CTA/PE heart > 30 kg**
- T-spine
- L-spine
- Chest/Abdomen/Pelvis (trauma, tumor)
- Liver
- Renal stone
- Appendicitis
- Pancreas
- Kidneys (donor)

Noise index and patient size

	kV	mA	CTDIvol	Eff.mAs	Collimation	NI
Abdomen NICU ONLY (Volume)	100	150	2.3	53	0.5 x 320	***
Abd/Pelvis (>15 kg)	120	R300	7.8	3	0.5 x 80	7.5
Abd/Pelvis (16-30 kg)	120	R350	8.6	5	0.5 x 128	10
Abd/Pelvis (31-45 kg)	120	R230	6.2	6	0.5 x 160	12.5
Abd/Pelvis (46-60 kg)	120	R160	5.2	6	0.5 x 160	15
Trauma Abd/Pelvis Child	120	R350	10.2	5	0.5 x 128	8

Table 2

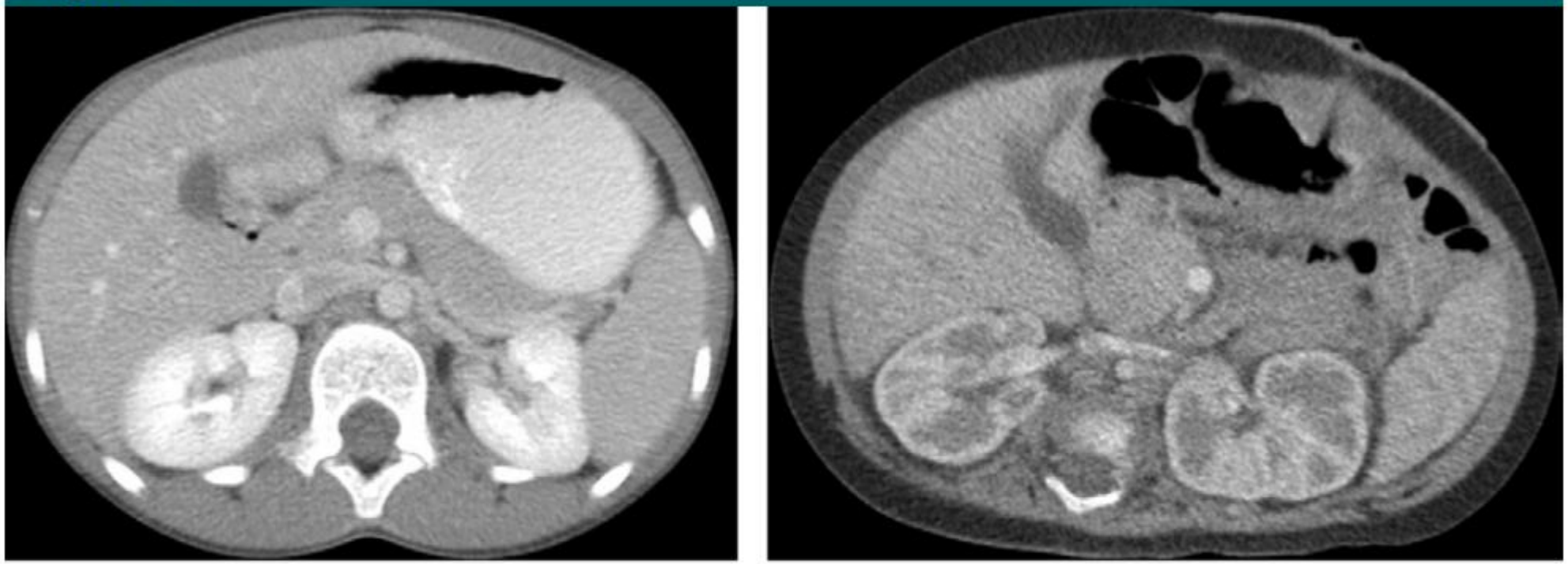
Patient Size Compared with Tube Voltage

BW Group	Group Scanned at 80 kV	Group Scanned at 90 kV	Group Scanned at 100 kV	Group Scanned at 120 kV	Group Scanned at 140 kV
<15 cm	1/21 (5)	4/21 (19)	2/21 (10)	14/21 (67)	0/21 (0)
15–19 cm	1/153 (1)	2/153 (1)	37/153 (24)	113/153 (74)	0/153 (0)
20–24 cm	0/286 (0)	0/286 (0)	64/286 (22)	221/286 (77)	1/286 (0)
25–29 cm	0/326 (0)	0/326 (0)	34/326 (10)	285/326 (87)	7/326 (2)
⩾30 cm	0/168 (0)	0/168 (0)	8/168 (5)	158/168 (94)	2/168 (1)

Note.—Data are numbers of patients. Numbers in parentheses are percentages, and percentages were rounded.

Goske et al. Diagnostic reference ranges for pediatric abdominal CT. Radiology. 2013 Jul;268(1):208-18. doi: 10.1148/radiol.13120730. Epub 2013 Mar 19.

Figure 6



a. b.

Figure 6: **(a)** Representative axial image from a CT scan of the abdomen at the level of the gallbladder used during image quality analysis subjectively ranked as diagnostic by the investigators. The patient BW was 19 cm (infant), and the SSDE was 4.7 mGy (120 kV). **(b)** Representative axial image from a CT scan of the abdomen and pelvis during the same image quality analysis was ranked as nondiagnostic by site investigators. The patient's BW was 19 cm (infant), and the SSDE was 3.1 mGy (90 kV).

Goske et al. Diagnostic reference ranges for pediatric abdominal CT. Radiology. 2013 Jul;268(1):208-18. doi: 10.1148/radiol.13120730. Epub 2013 Mar 19.

11 year old
4D Dynamic
Lung

14 mGy
100 kVp, 52.5 mAs

2 year old
4D Dynamic
Lung

8.1 mGy
80 kVp, 15 mAs

ACR accreditation

- New definition of pediatric patient
  - ≤ 18 years as of 7/27/15
- When do you need to submit pediatric patient images?
  - If you ever scan even **ONE** pediatric patient

Overview

The CT Accreditation Program involves the acquisition of clinical and phantom images, dose measurements, and the submission of scanning protocols. Every unit used to produce diagnostic clinical images for patients must successfully pass accreditation testing for the facility to be accredited. Facilities that use units that have been withdrawn, expired, or failed accreditation testing or facilities that never submit a unit for accreditation testing are subject to revocation of their accreditation. Such revocation could adversely affect reimbursement. Every unit must apply for all modules routinely performed on that unit for a facility to be accredited. For sites that perform only adult CT scanning, clinical images required for submission will be in the modules routinely performed on that unit. For sites that do occasional pediatric scanning (≤ 18 years of age) in addition to adult work, an additional exam performed on a child will also have to be selected for submission. Sites that perform only pediatric examinations (***only*** patients who are ≤ 18 years of age) will have to submit exams tailored to the pediatric population (see selection list under Clinical Images section for all three patient type scenarios).

Outline

- How is the pediatric patient different?
- Pediatric patient age and size
- The most common CT scan in the ER
- Step-by-step approach to optimizing pediatric protocols
- Notes for the medical physicist
- Notes for the technologists

- The most common mistake – not securing the patient
  - Will result in a re-scan
  - Swaddle, swaddle, swaddle

- With pediatric patients, dose is on everyone's mind

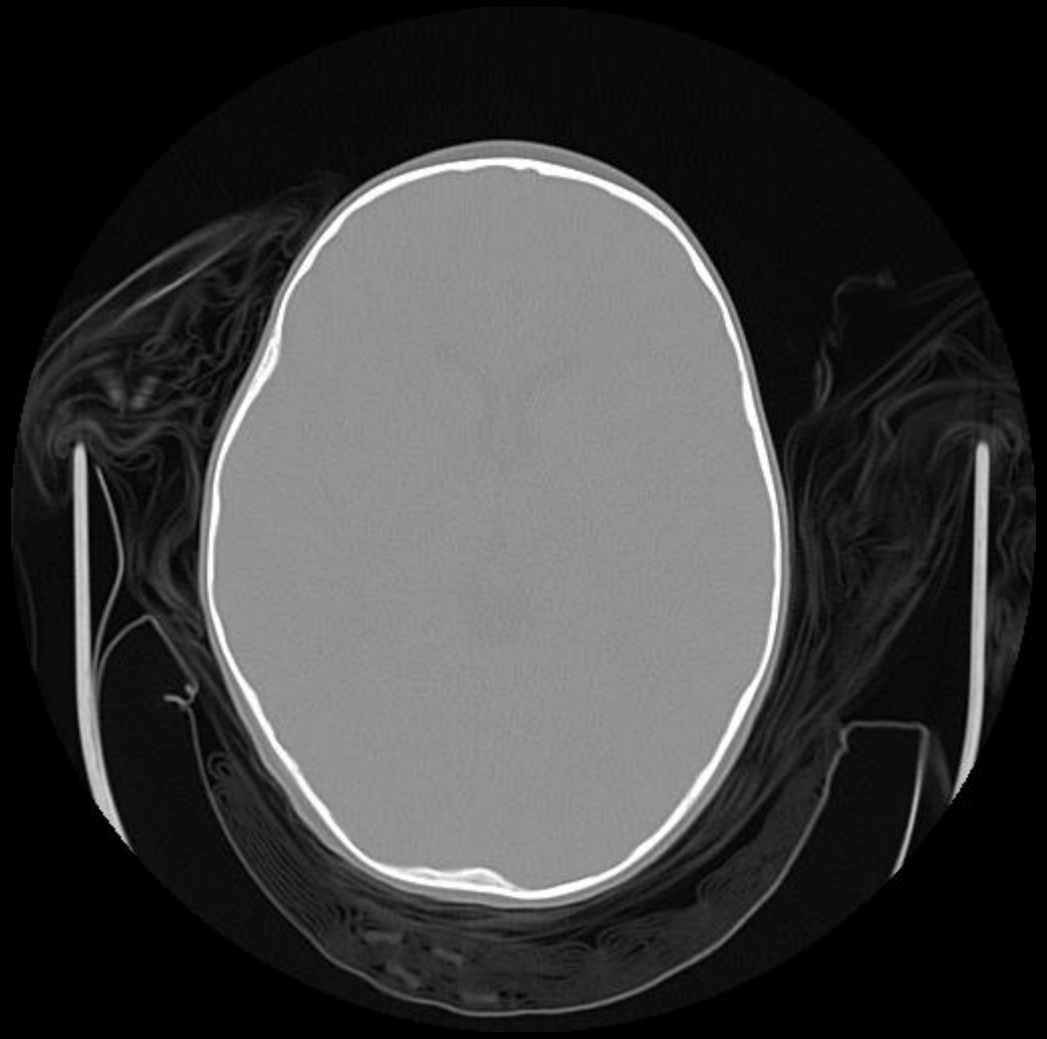
Understand what kids can and can’t do

- They won’t hold still for very long
  - Be watchful and take that window of opportunity to scan when you can
  - If missed, not likely to get another one
- Even for abd/pel scans, put the kids in the head holder and scan head first
  - Otherwise they will prop their feet on the gantry and try to get out

Sedation

- 2 patients/week require sedation
  - Biopsies
  - Patients with developmental or intellectual delays (Down syndrome, Autism)
- Swaddle, swaddle, swaddle
- Child life department

Minimizing sedation by Swaddling



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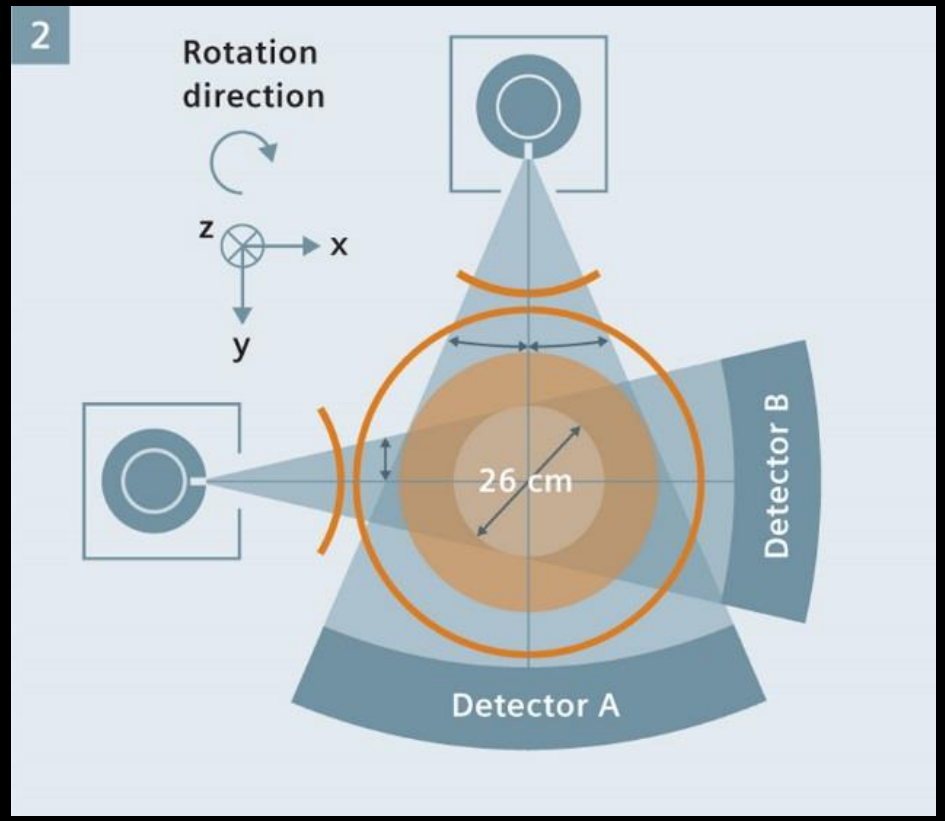
Minimizing sedation by protocol optimization

- Take advantage of the features available on your system
- Fastest rotation time
- Highest pitch that the radiologists will accept
- Volume scanning
- Projector or TV screen

New Features

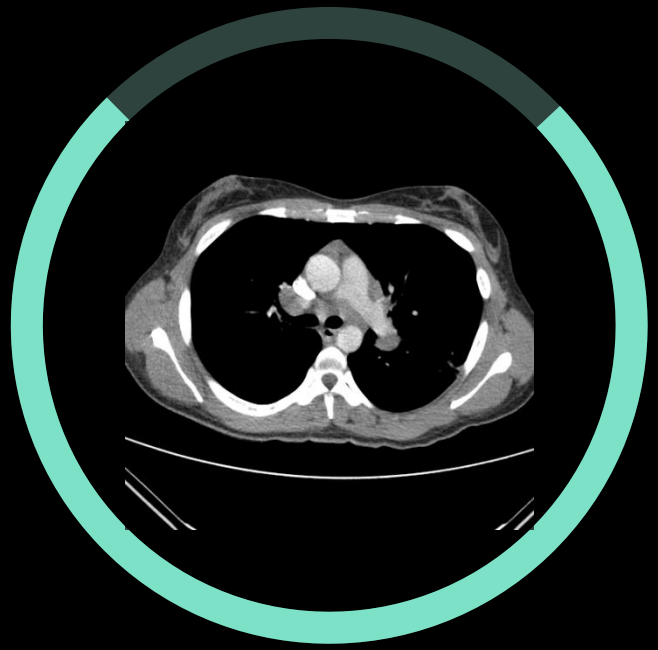


http://health.siemens.com/ct_applications/somatomsessions/wp-content/uploads/2015/12/S_DSCT_Fig2.jpg

Curtesy of Toshiba

Organ-based tube current modulation

Conventional



Organ-Based Modulation

Minimizing sedation by protocol optimization

- Allow kids to hold toys or pacifiers
- Parents/caregivers can stay next to the table

IV contrast and delay timing

- Contrast by weight and body region:
  - 1.5 mL/kg for chest
  - 2 mL/kg for abdomen and pelvis
  - 2.5 mL/kg for CTA

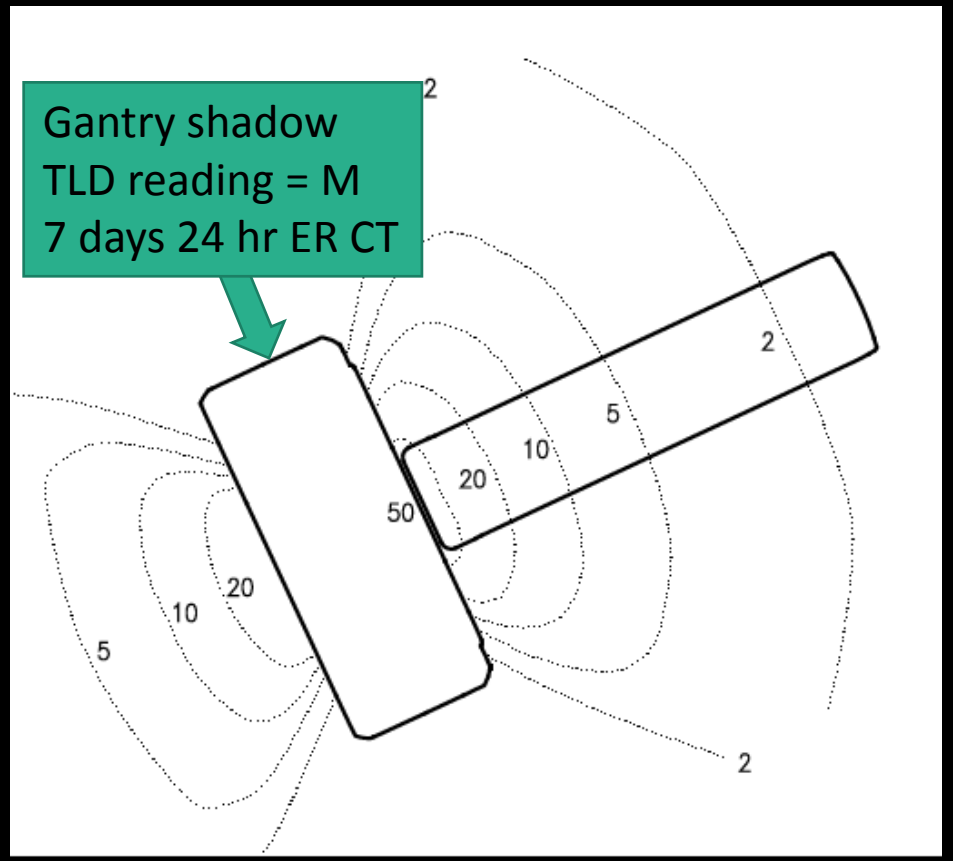
IV contrast and delay timing

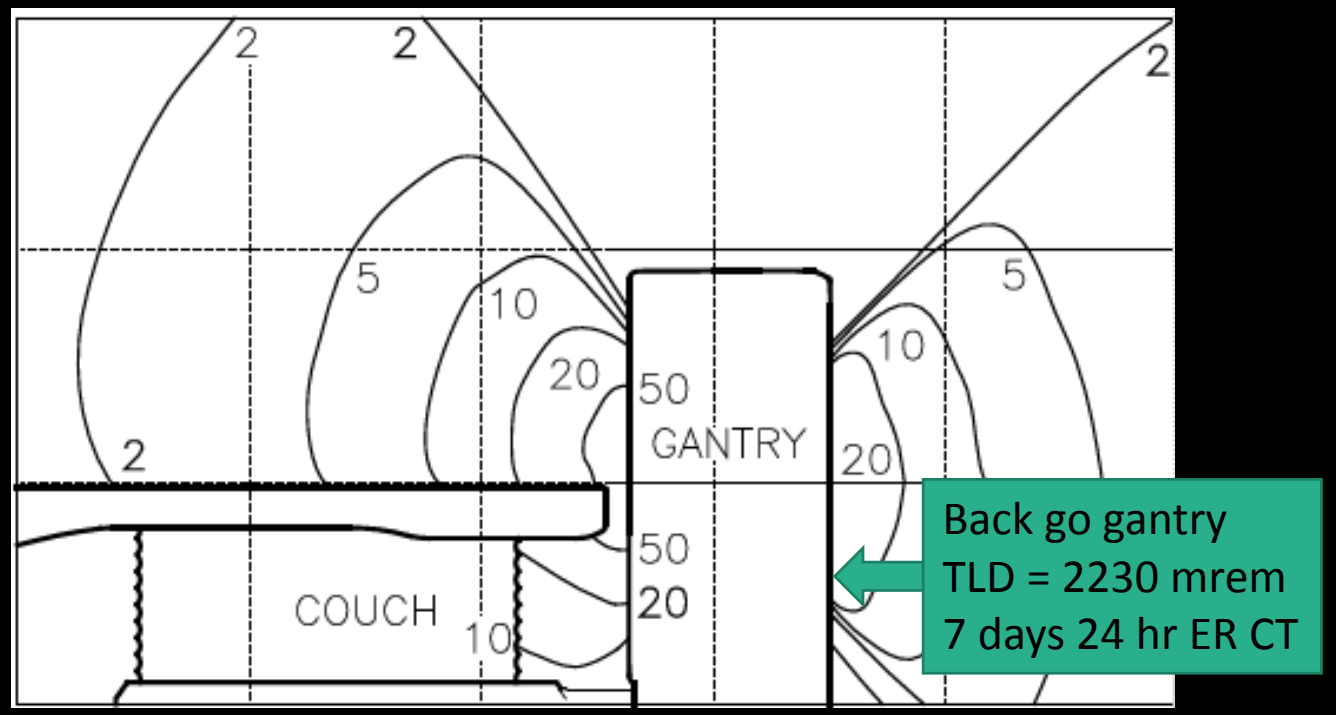
- Contrast depends on the age, IV location and exam:
  - 2 mL/sec for babies – up to 13 mL total
  - 2.5 mL/sec for small infants and when you don't want to blow the IV
  - 4-4.5 mL/sec for children – 70-90 mL total
    - Faster rates for imaging the coronary arteries (it will cause them to open up more)
  - 3-3.5 mL/sec if you can't go to 4-4.5 because of a bad IV or if it is in the foot

Radiation safety: staff holding the patient

	Monitoring Period	Total DDE	Total LDE	Total SDE
Lead technologist	2015	89	89	84
Day technologist1	2015	M	M	M
Day technologist2	2015	58	57	54
Evening technologist1	2015	M	M	M
Evening technologist2	2015	4	4	4
Weekend technologist1	2015	M	M	M
Weekend technologist2	2015	M	M	M

Radiation safety: parents holding the patient





Thank you!

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