How and Why to Choose Wisely and Image Gently

ALLISON VITTER MD

PEDIATRIC RADIOLOGY

Introduction to Peds Radiology Staff

- Chris Arcement
  - Fellowships in Pediatric Body and Pediatric Neuroradiology

Introduction to Peds Radiology Staff

- Jane Congeni
  - Fellowship trained in Pediatric Body

Introduction to Peds Radiology Staff

- Marie Louise Haymon
  - Fellowship trained in Pediatric Body

MOST IMPORTANT SLIDE

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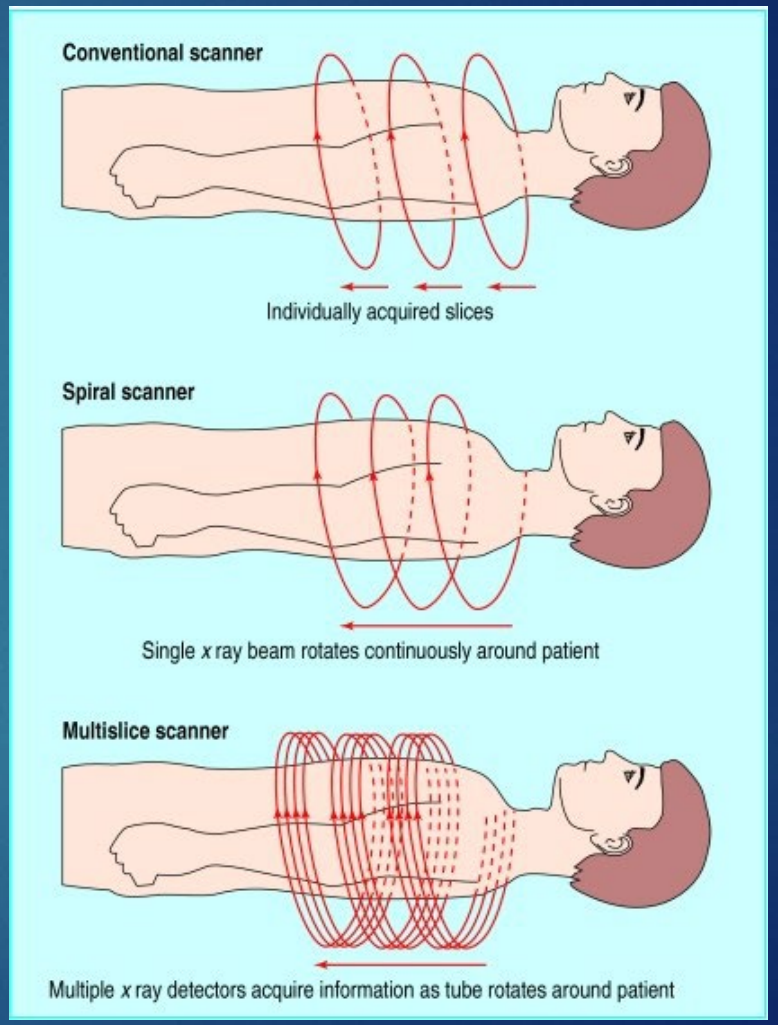
Objectives

- History of CT
- How do we estimate radiation dose?
- What are the risks?
- Why CT?
- What can we do?

RA Schulz, J Med Imaging 2021

Brief History Lesson

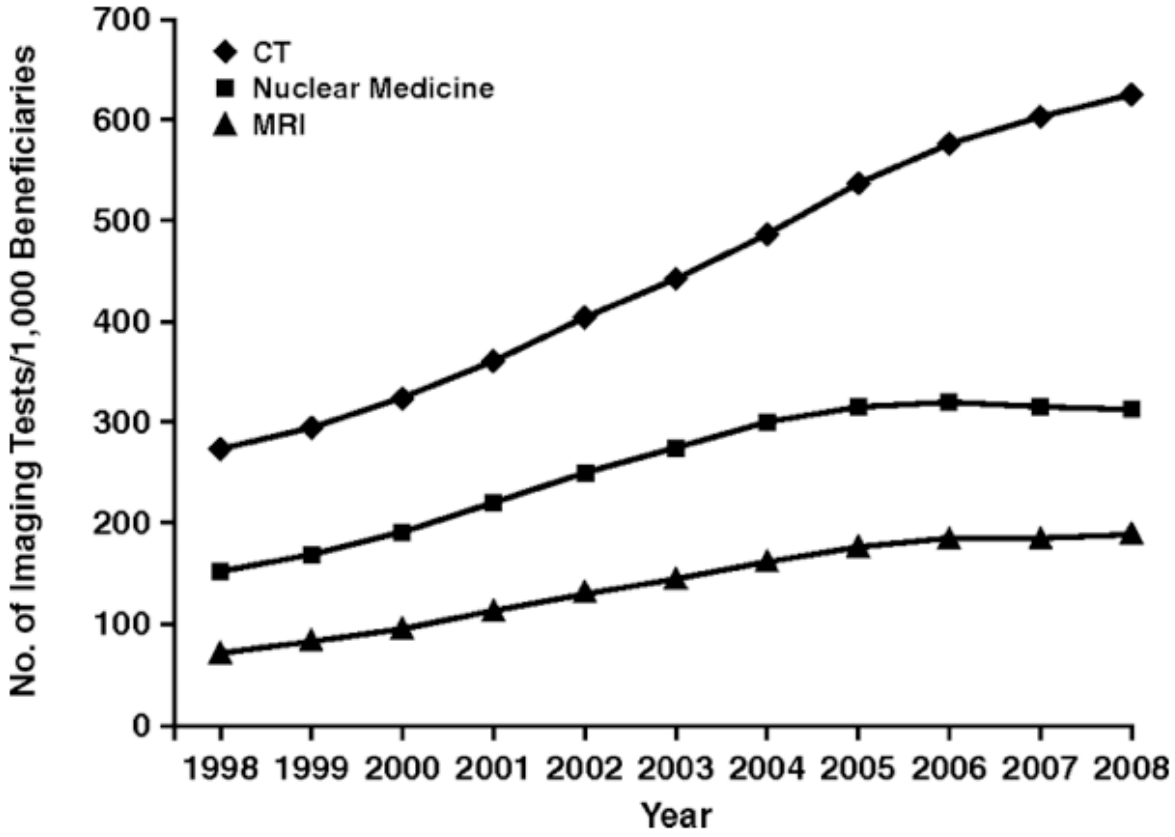
- First CT exam 1970s
- 30 minutes



Reid J, AJR Vol 195, Issue 4

Brief History

—Utilization rates of CT (♦); nuclear medicine, including positron emission tomography (▪); and MRI (▲) in Medicare fee-for-service population, 1998–2008.



Levin D C et al. AJR 2011;196:W25-W29

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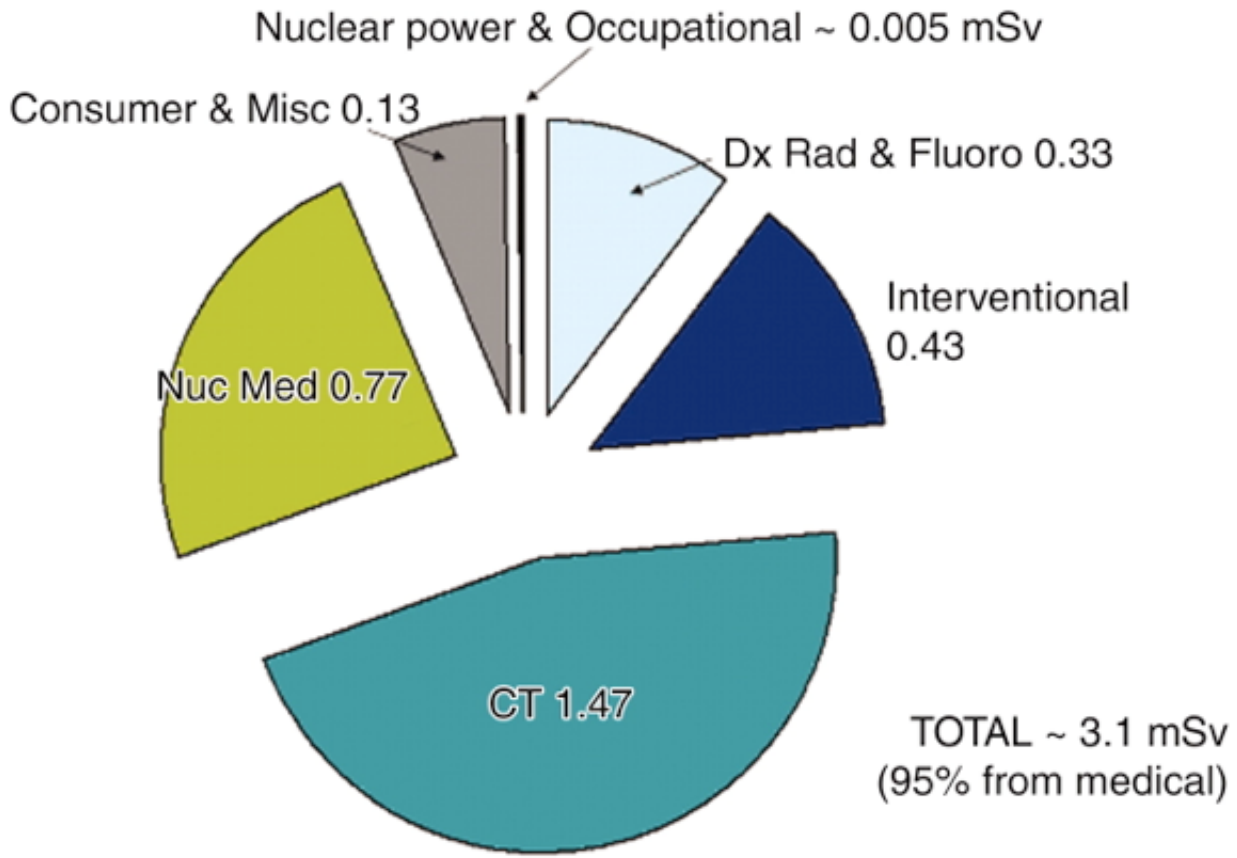
AJR

Annual per-capita effective radiation dose from man-made sources in the United States for 2006 (14).



Mettler F A et al. Radiology 2009;253:520-531

Radiology

©2009 by Radiological Society of North America

4 month old with abnormal echo

Objectives

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sunnuclear.com/Products/Ctdi-phantoms

What is the average annual dose from background radiation?

- 0 mSv
- 3 mSv
- 12 mSv
- 50 mSv

Radiation Dose Estimates

- CT Dose Index (CTDIvol)
- Dose Length Product (DLP)
- Effective Dose

Radiation Dose

Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy*cm)	Phantom cm
LUNG CTA					
203	SmartPrep	I49.563-I49.563	0.25	0.13	Body 32
204	SmartPrep	I44.713-I44.713	0.26	0.13	Body 32
205	SmartPrep	I40.556-I40.556	0.25	0.13	Body 32
205	SmartPrep	I40.556-I40.556	1.28	0.64	Body 32
			Total Exam DLP:	22.95	

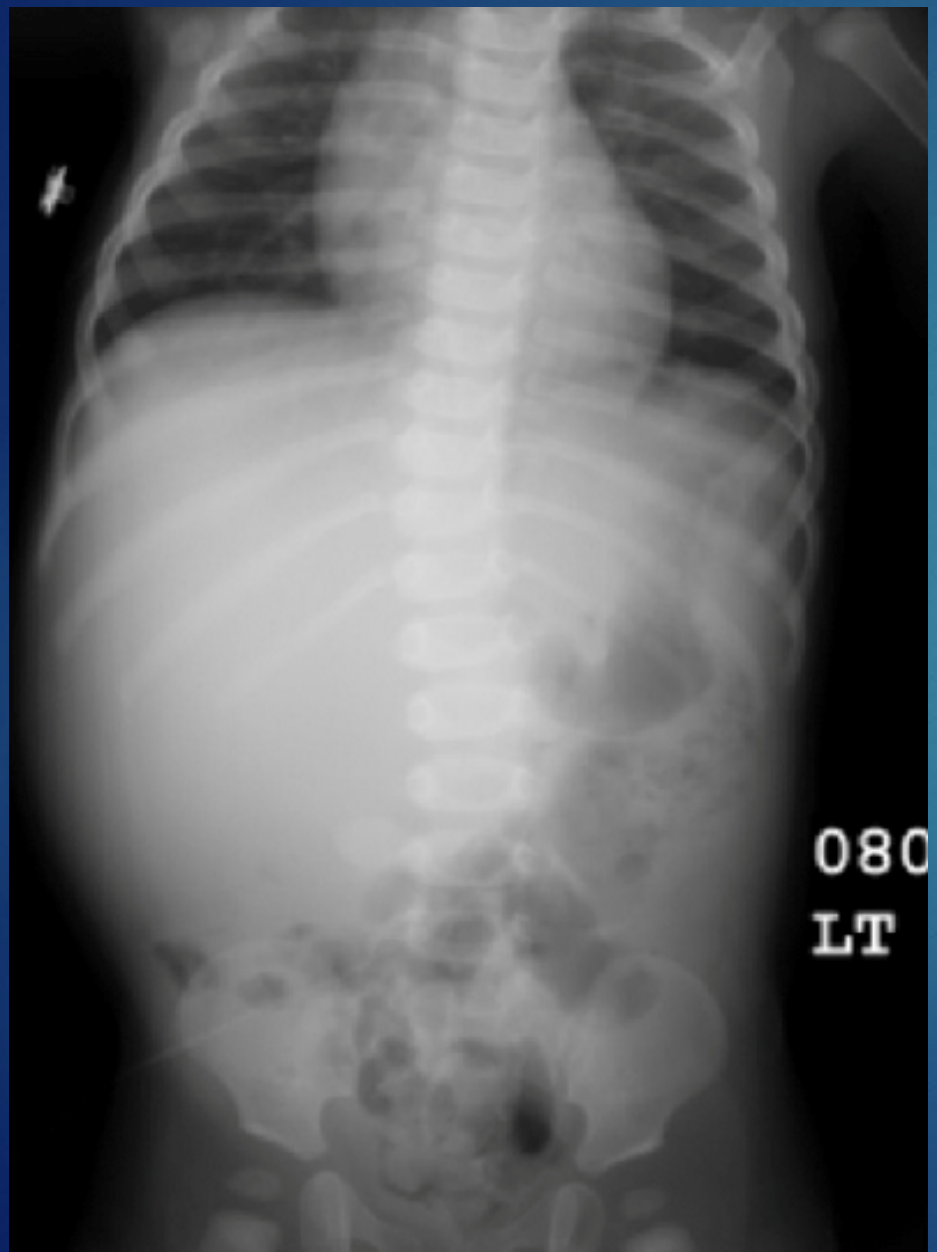
2/2

Radiation Dose

- Radiation dose output measured using standard phantom
- Used by ACR to ensure scanners are up to code
- Assess changes in dose when changing protocols
- Does **NOT** equal dose patient received

sunnuclear.com/Products/Ctdi-phantoms

3 year old with abdominal pain



Radiation Dose Estimates

- Effective Dose (Sv or mSv)
  - Radiation risk averaged over entire body
  - Unit used to discuss radiation effects relative to cancer induction
  - Allows us to compare dose between CT, x ray, etc

Dose Estimates

How much radiation is used in paediatric radiology examinations compared to other exposures?

	Estimated dose	Days of background radiation
Natural background	3 mSv/year	1 day
Airline passenger	0.04 mSv	4 days
Chest X-ray	0.01 mSv	1 day
Head CT	2 mSv	8 months
Chest CT	3 mSv	12 months
Abdominal CT	5 mSv	20 months
Angiography or venography	11-33 mSv	4-11 years
CT guided intervention	11-17 mSv	4-6 years

www.imagegently.org

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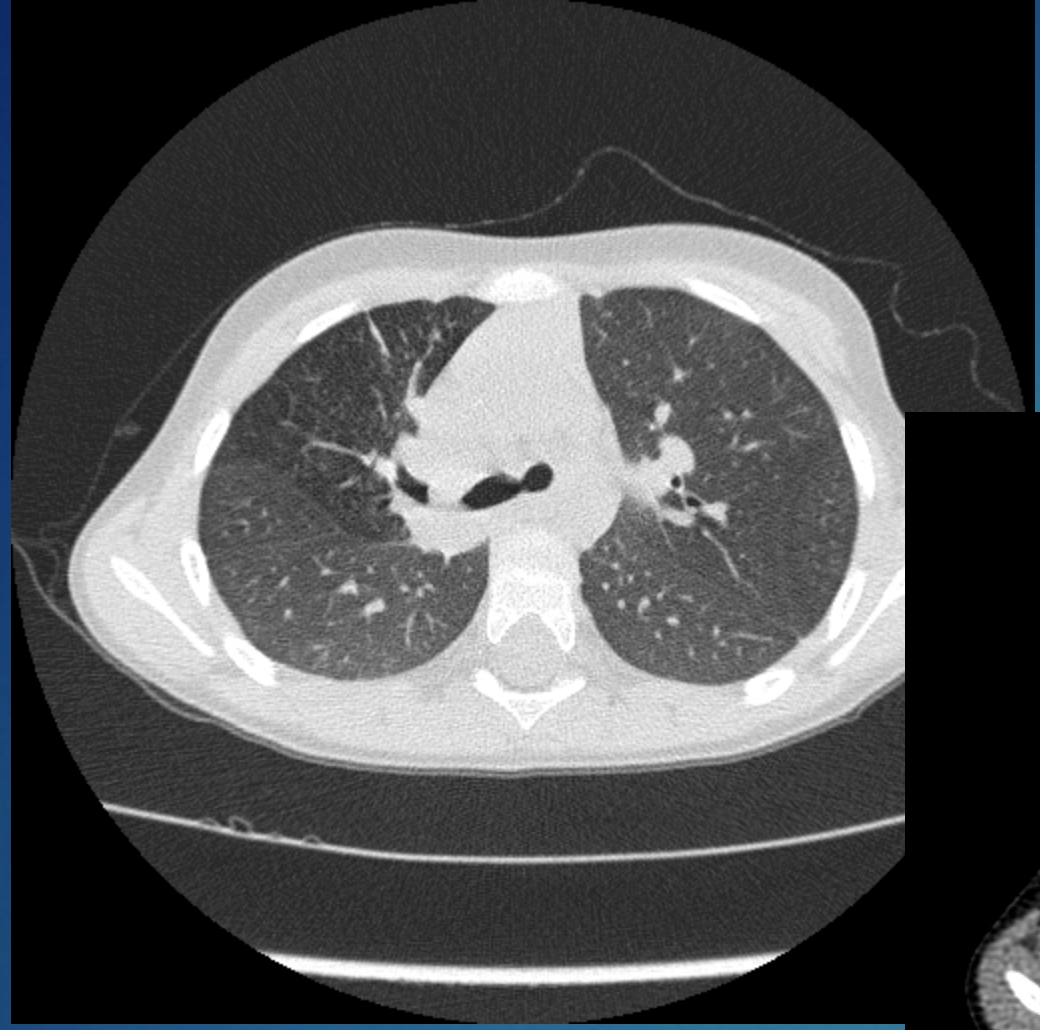
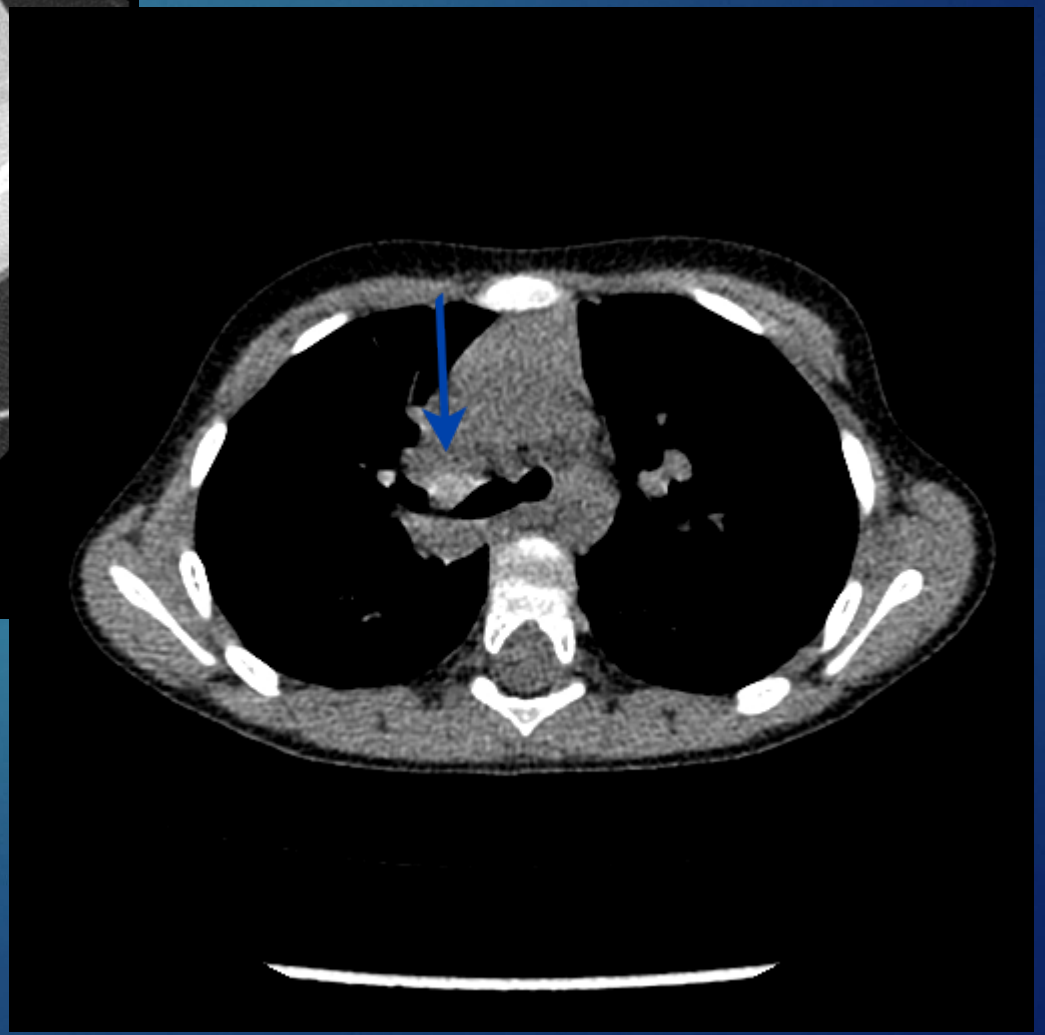
What are the risks?

- Deterministic
  - Predictable tissue effects for which there is a threshold below which these do not occur
  - Severity increases with increased dose
  - Ex: Lens of the eye (cataracts), skin (hair loss, skin burns)

- Stochastic
  - Random and cannot be predicted
  - No threshold below which effects are zero
  - Ex: Cancer Induction, Genetic Changes

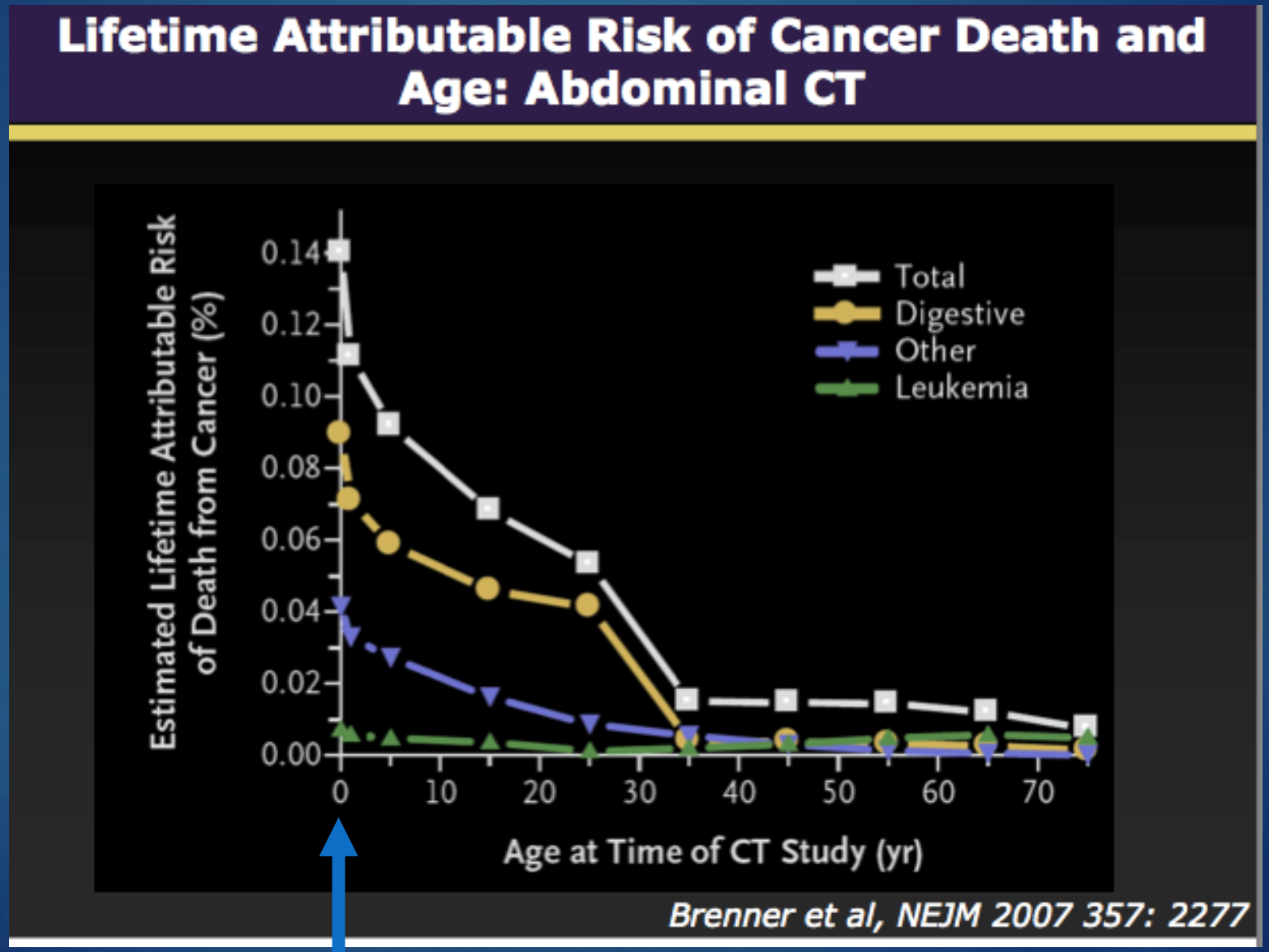
5 year old with recurrent RUL pneumonia





5 year old with recurrent RUL pneumonia

What is the risk?



What is the risk?

- Increased dose due to relatively smaller organs
- Rapidly dividing cells are more sensitive
- Longer life span
  - Leukemia – 5-15 years
  - Solid Organ malignancies – 10-60 years

What is the risk?

- We don't know
- Good data at high radiation exposure levels (atomic bomb survivors)
- No comprehensive study showing effects at low radiation levels
  - Long latency
  - Many other carcinogens
  - Many malignancies occur spontaneously

Objectives

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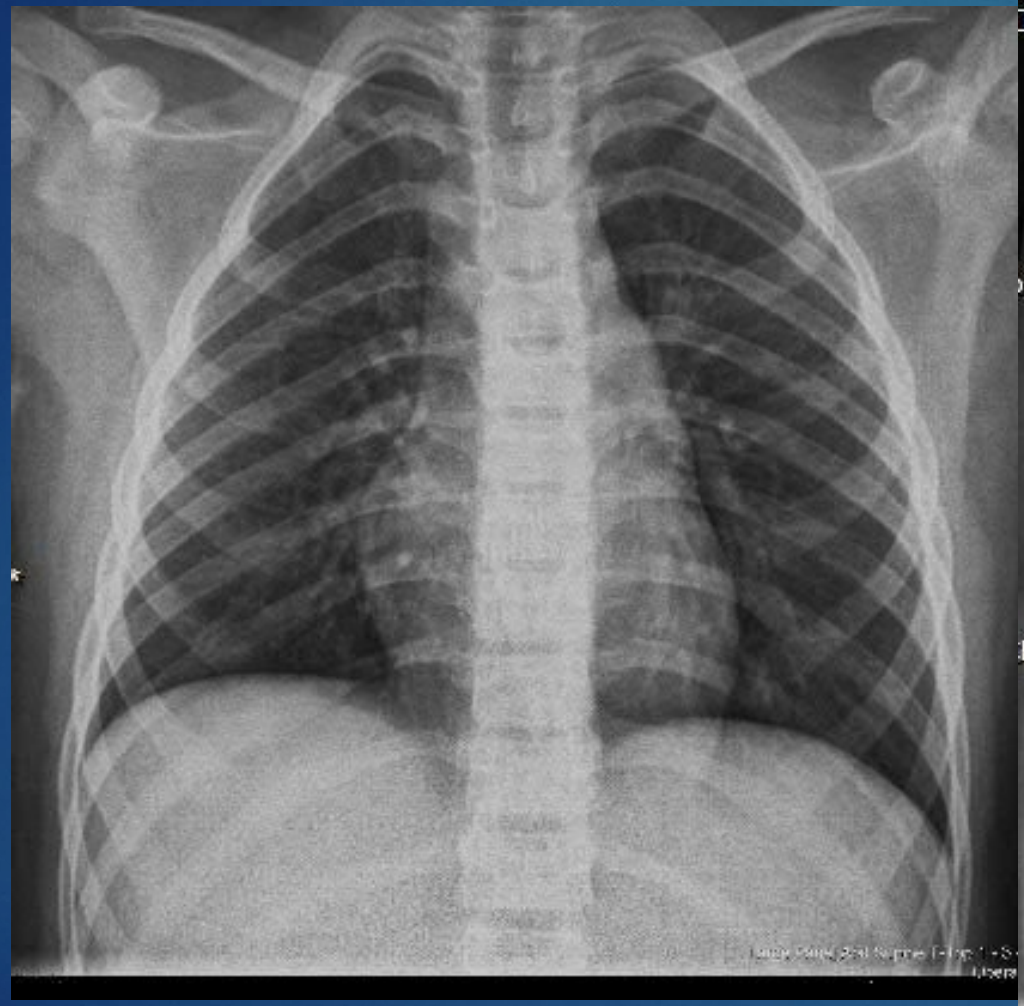
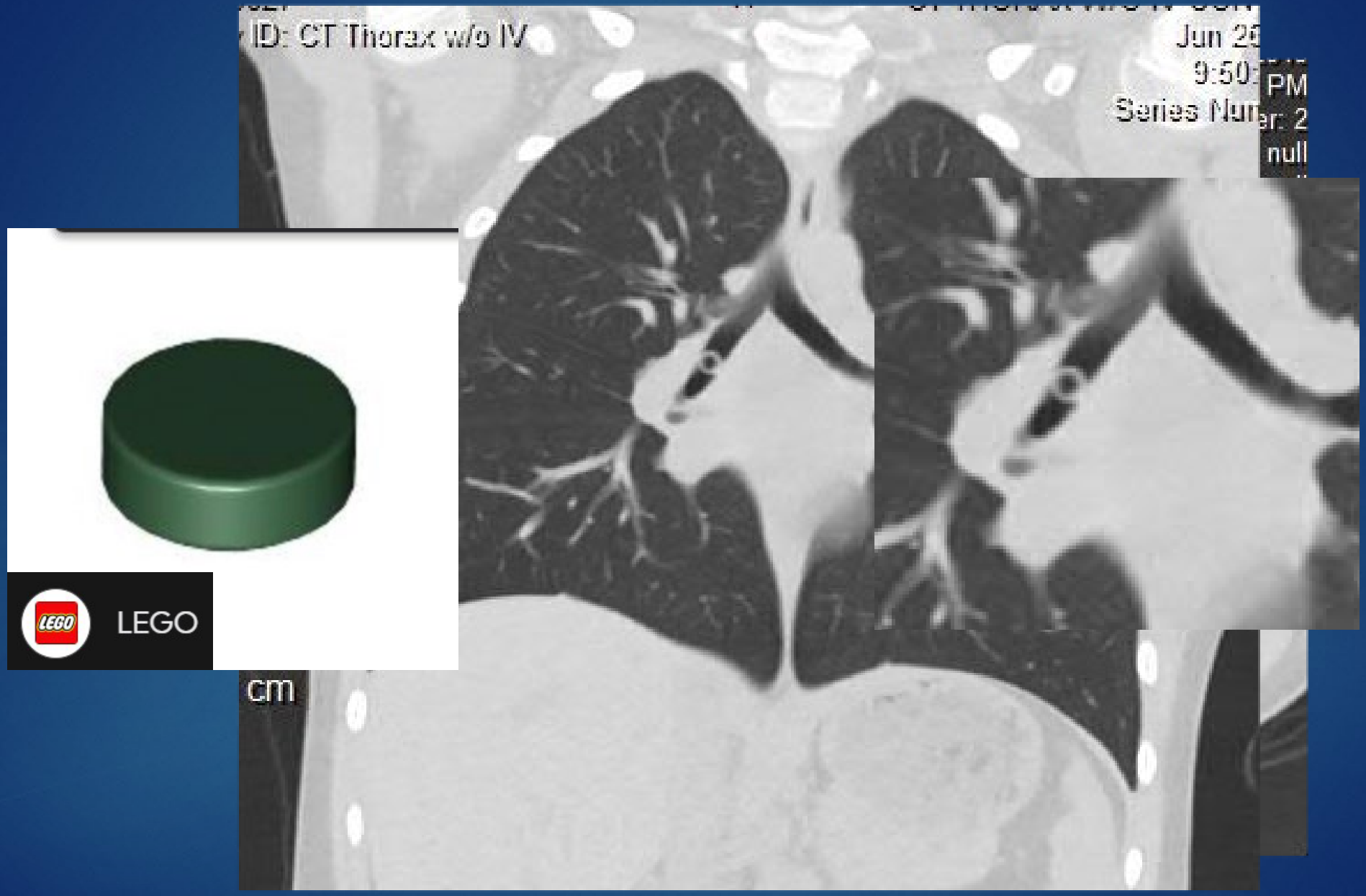
emojipedia.org/exploding-head/

Why CT?

- Invaluable diagnostic tool
- Fast
  - In many cases no sedation
  - More readily available than MRI
- In many cases cheaper than MRI

Possible Foreign Body




ID: CT Thorax w/o IV
Jun 25
PM
null
LEGO
cm

Objectives

- History of CT
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- What are the risks?
- Why CT?
- What can we do?

- Alliance for Radiation Safety in Pediatric Imaging founded by:
  - Society of Pediatric Radiology
  - American Association of Physicists in Medicine
  - American College of Radiology
  - American Society of Radiologic Technologists

Image Gently

What can we do?

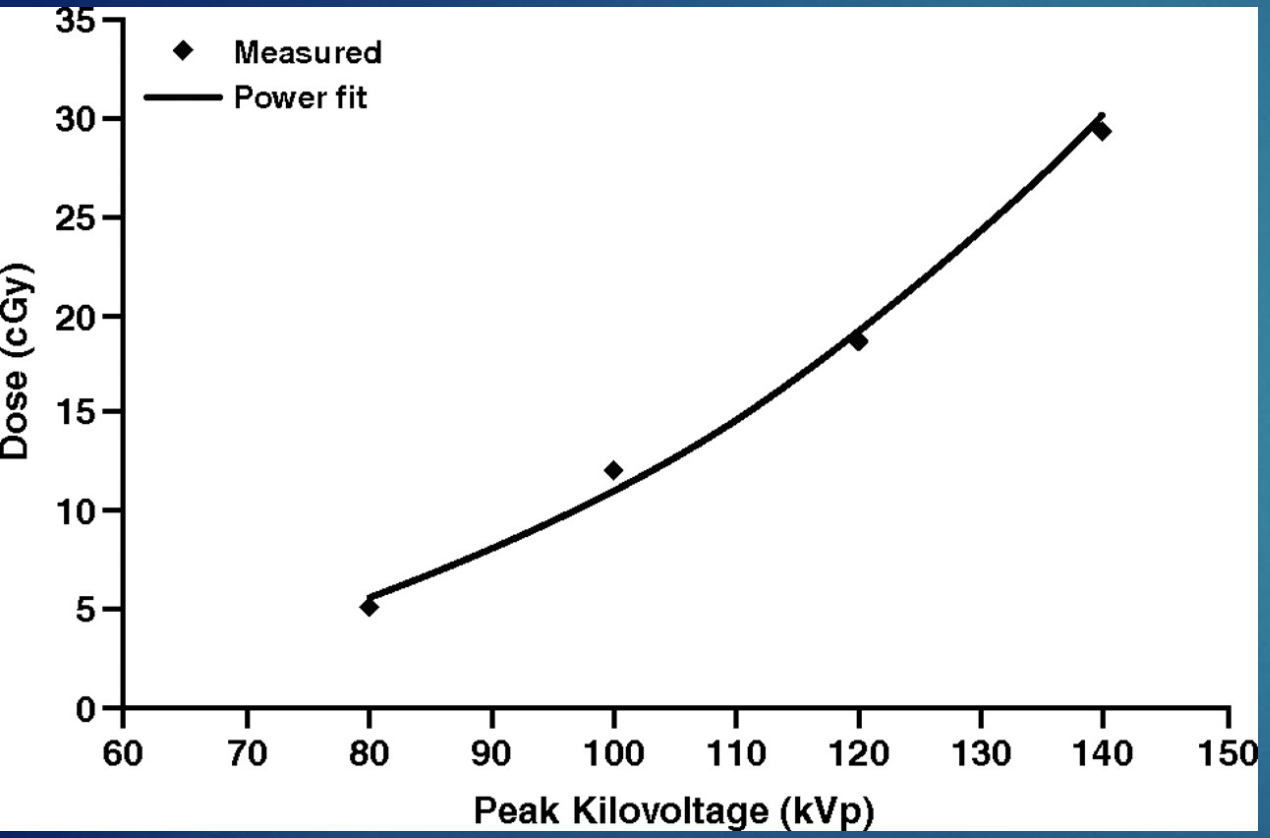
- Ensure that CT is the most appropriate exam
  - Call Peds Rad
  - ACR Appropriateness Criteria
- Child size the dose - as low as reasonably achievable (ALARA)
- Use single phase scanning
- Limit the imaging field when possible (ex: pectus excavatum)

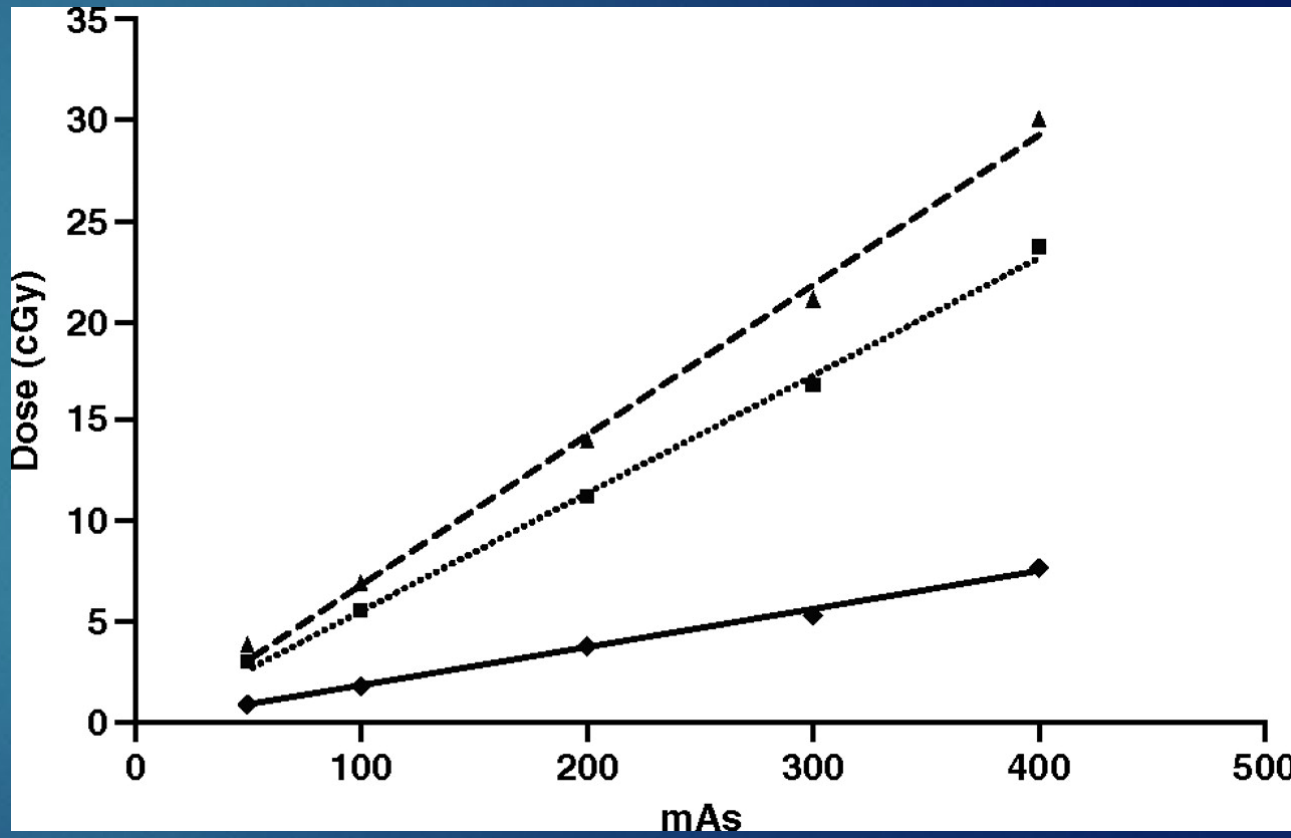
image gently®

Child Size Dose

- Use pediatric protocols with pediatric parameters
  - Built into our scanners
- Variables we routinely adjust
  - kVp
  - mA

Child Size Dose





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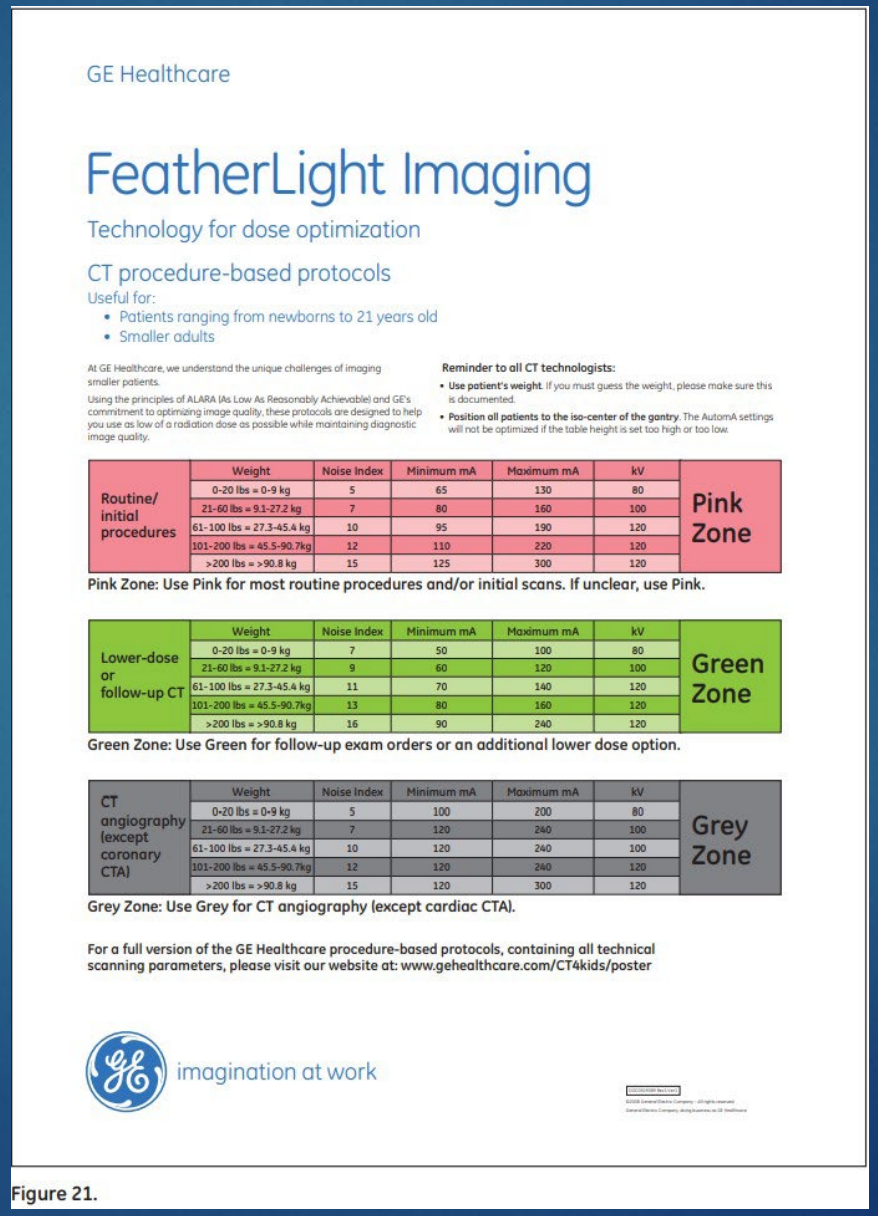
Child Size Dose



GE Healthcare

FeatherLight Imaging

Technology for dose optimization

CT procedure-based protocols

Useful for:

- Patients ranging from newborns to 21 years old
- Smaller adults

At GE Healthcare, we understand the unique challenges of imaging smaller patients.

Using the principles of ALARA (As Low As Reasonably Achievable) and GE's commitment to optimizing image quality, these protocols are designed to help you use as low of a radiation dose as possible while maintaining diagnostic image quality.

Reminder to all CT technologists:

- **Use patient's weight**. If you must guess the weight, please make sure this is documented.
- **Position all patients to the iso-center of the gantry**. The AutomA settings will not be optimized if the table height is set too high or too low.

	Weight	Noise Index	Minimum mA	Maximum mA	kV	
Routine/ initial procedures	0-20 lbs = 0-9 kg	5	65	130	80	Pink Zone
	21-60 lbs = 9.1-27.2 kg	7	80	160	100	
	61-100 lbs = 27.3-45.4 kg	10	95	190	120	
	101-200 lbs = 45.5-90.7kg	12	110	220	120	
	>200 lbs = >90.8 kg	15	125	300	120	

Pink Zone: Use Pink for most routine procedures and/or initial scans. If unclear, use Pink.

	Weight	Noise Index	Minimum mA	Maximum mA	kV	
Lower-dose or follow-up CT	0-20 lbs = 0-9 kg	7	50	100	80	Green Zone
	21-60 lbs = 9.1-27.2 kg	9	60	120	100	
	61-100 lbs = 27.3-45.4 kg	11	70	140	120	
	101-200 lbs = 45.5-90.7kg	13	80	160	120	
	>200 lbs = >90.8 kg	16	90	240	120	

Green Zone: Use Green for follow-up exam orders or an additional lower dose option.

	Weight	Noise Index	Minimum mA	Maximum mA	kV	
CT angiography (except coronary CTA)	0-20 lbs = 0-9 kg	5	100	200	80	Grey Zone
	21-60 lbs = 9.1-27.2 kg	7	120	240	100	
	61-100 lbs = 27.3-45.4 kg	10	120	240	100	
	101-200 lbs = 45.5-90.7kg	12	120	240	120	
	>200 lbs = >90.8 kg	15	120	300	120	

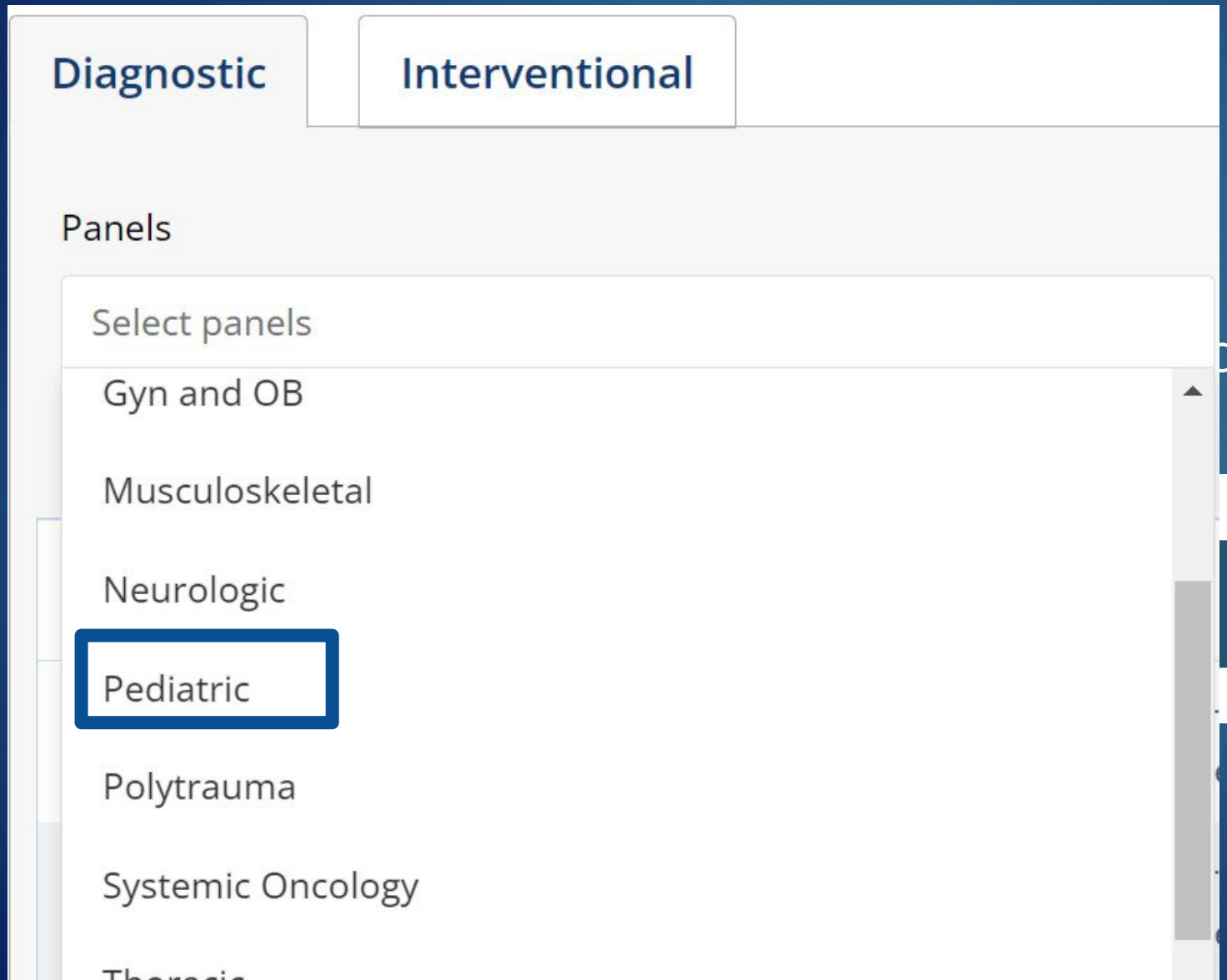
Grey Zone: Use Grey for CT angiography (except cardiac CTA).

For a full version of the GE Healthcare procedure-based protocols, containing all technical scanning parameters, please visit our website at: www.gehealthcare.com/CT4kids/poster

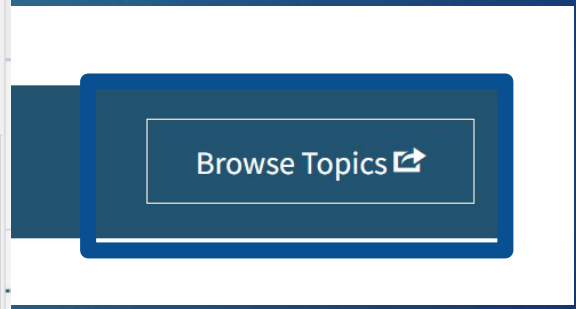
imagination at work

Figure 21.

Common CT indications



ateness-Criteria



Head CT

Variant 2: **Child. Secondary headache. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI head without IV contrast	Usually Appropriate	O
MRI head without and with IV contrast	Usually Appropriate	O
CT head without IV contrast	May Be Appropriate	☢☢☢
MR venography head without IV contrast	May Be Appropriate	O
MRA head without IV contrast	May Be Appropriate	O
CT venography head with IV contrast	May Be Appropriate	☢☢☢☢
CTA head with IV contrast	May Be Appropriate	☢☢☢☢
MR venography head with IV contrast	Usually Not Appropriate	O
Arteriography cerebral	Usually Not Appropriate	☢☢☢☢
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢☢
X-ray skull	Usually Not Appropriate	☢☢

Head CT

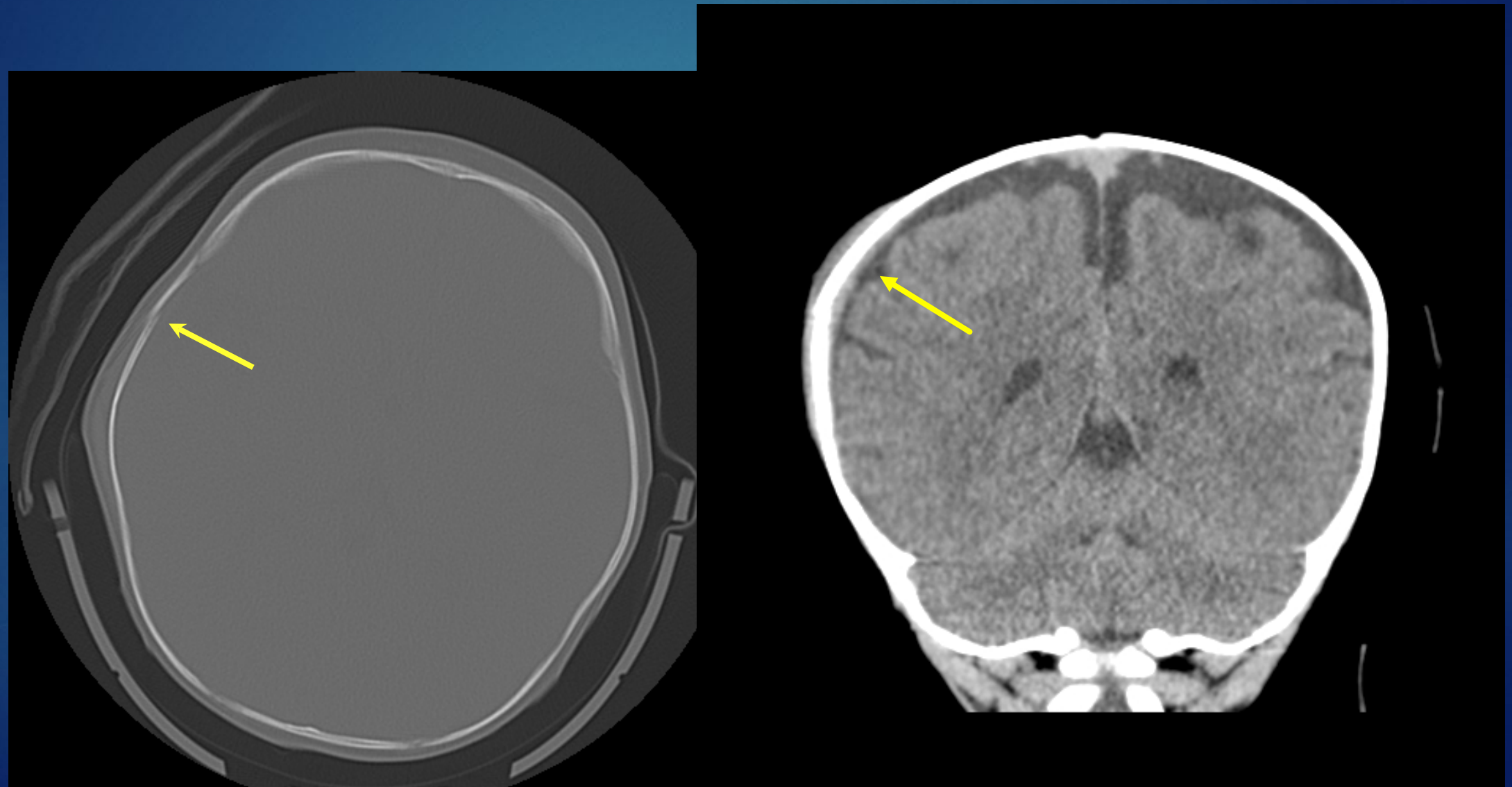
Variant 5: **Children 1 month to 17 years of age. Focal seizures, not including abusive head trauma. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI head without IV contrast	Usually Appropriate	O
MRI head without and with IV contrast	May Be Appropriate (Disagreement)	O
CT head without IV contrast	May Be Appropriate	☢☢☢
US head	Usually Not Appropriate	O
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢☢
HMPAO SPECT or SPECT/CT brain	Usually Not Appropriate	☢☢☢☢
FDG-PET/CT brain	Usually Not Appropriate	☢☢☢☢

Head (no IV contrast)

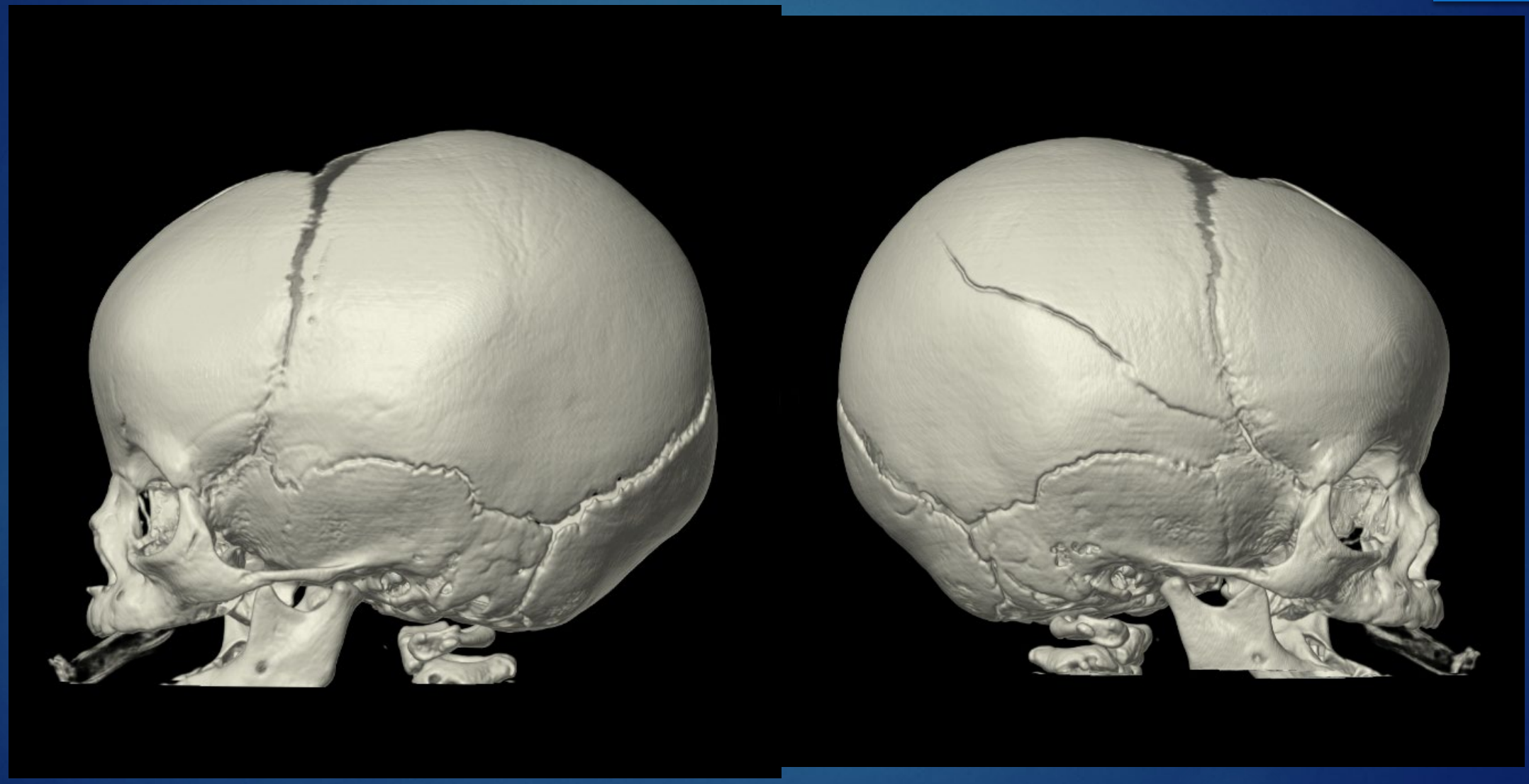
- Trauma
- Craniosynostosis
- Suspected Mass Effect

Trauma

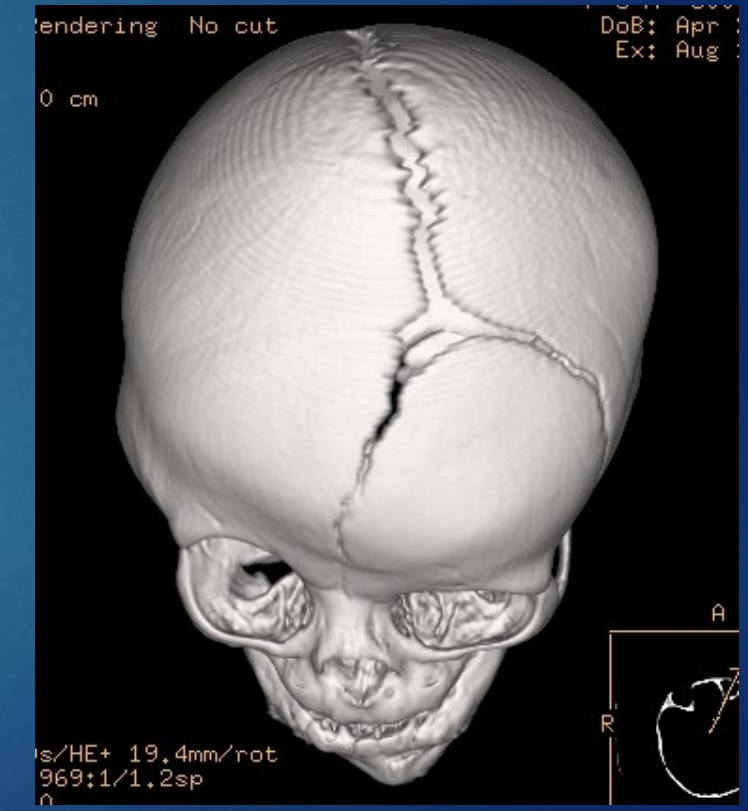


Normal

Fracture



Craniosynostosis



Neck (with IV contrast)

- Deep neck infection
- Malignancy
- *cervical lymphadenitis – start with ultrasound
- *congenital malformations – start with ultrasound

CT Neck

Variant 4: **Child. Neck mass(es). Not parotid region or thyroid. Initial imaging.**

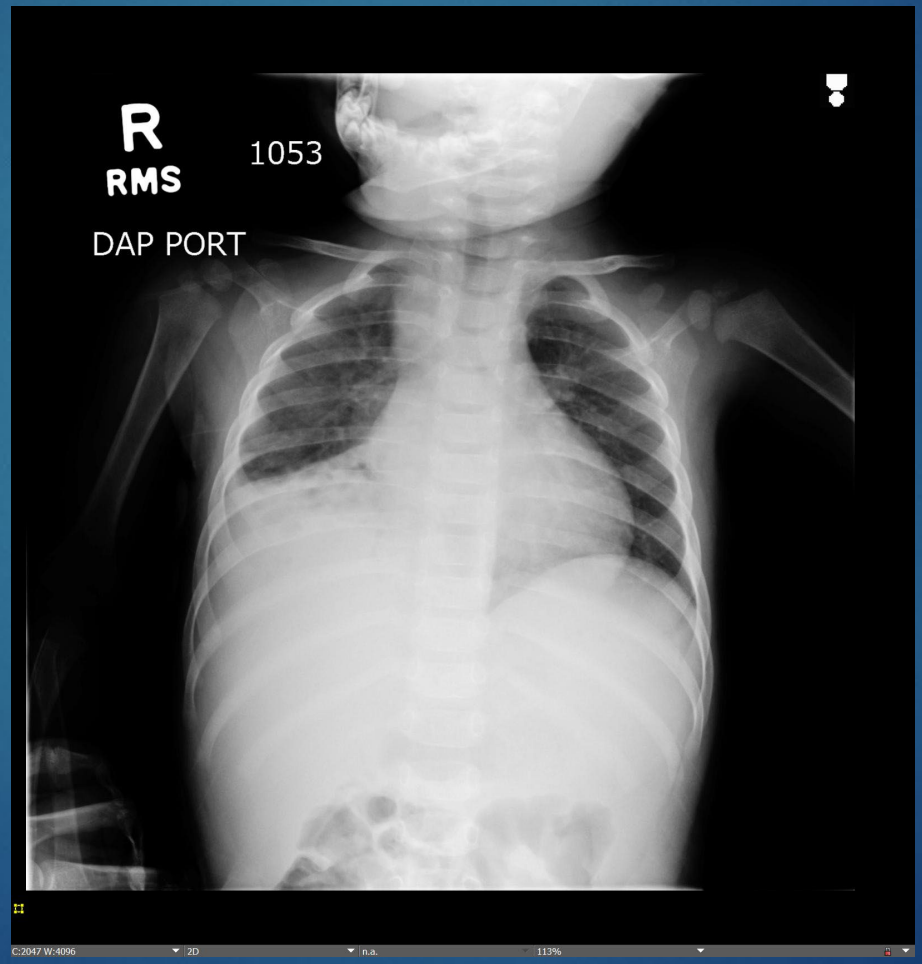
Procedure	Appropriateness Category	Relative Radiation Level
CT neck with IV contrast	Usually Appropriate	☢☢☢
MRI neck without and with IV contrast	Usually Appropriate	O
US neck	Usually Appropriate	O
MRI neck without IV contrast	Usually Appropriate	O
CT neck without IV contrast	May Be Appropriate (Disagreement)	☢☢☢
MRA neck without and with IV contrast	Usually Not Appropriate	O
MRA neck without IV contrast	Usually Not Appropriate	O
CT neck without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CTA neck with IV contrast	Usually Not Appropriate	☢☢☢
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢☢
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢☢☢
FDG-PET/MRI skull base to mid-thigh	Usually Not Appropriate	☢☢☢

Deep Neck Abscess

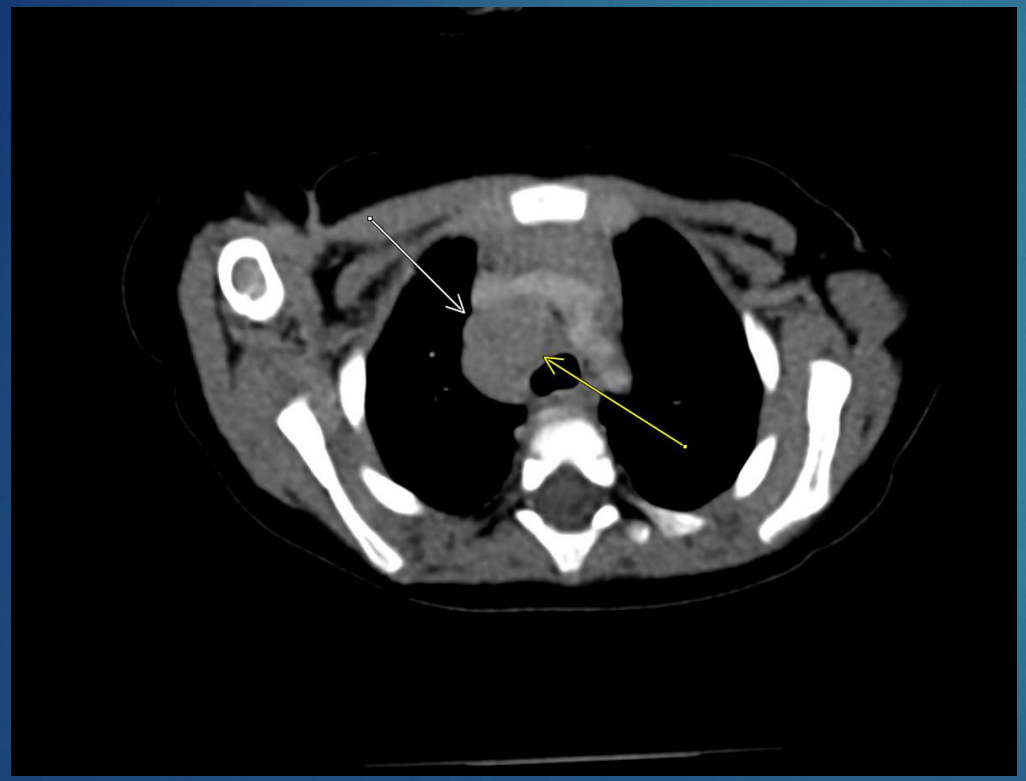
Chest

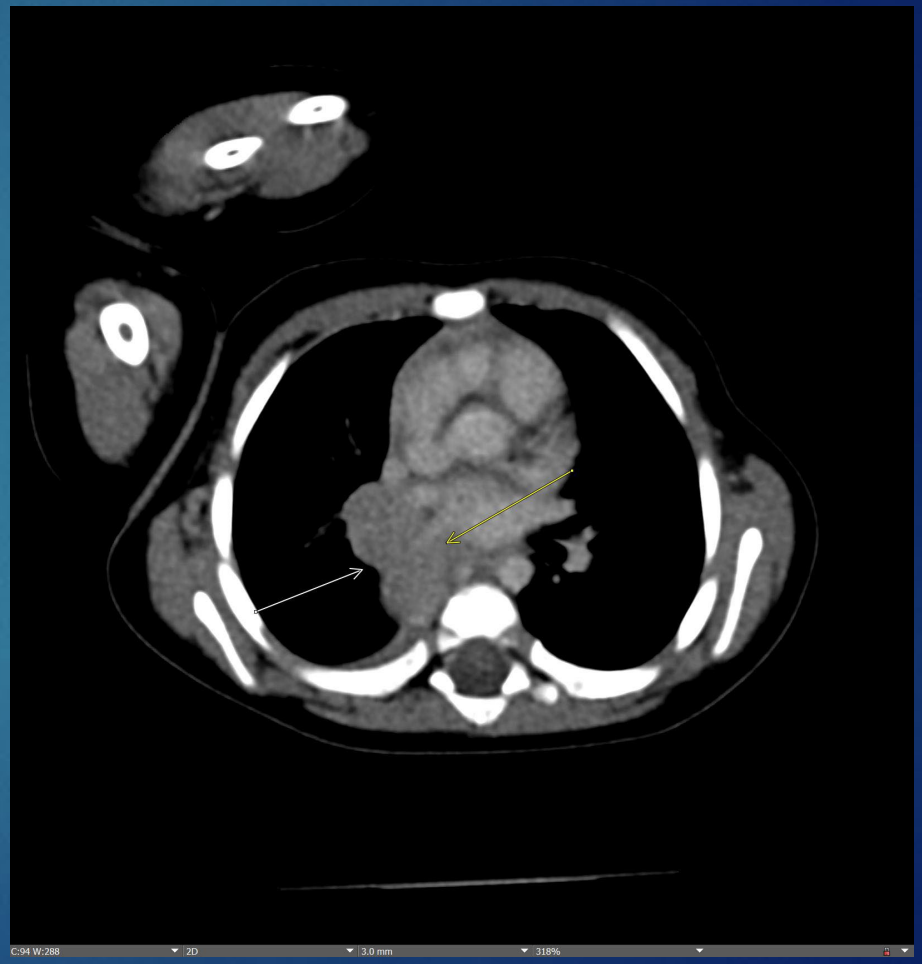
- Cardiovascular anomalies
- Complicated or recurrent pneumonia
- Pulmonary malformations
- Malignancy

10 month old with recurrent PNA

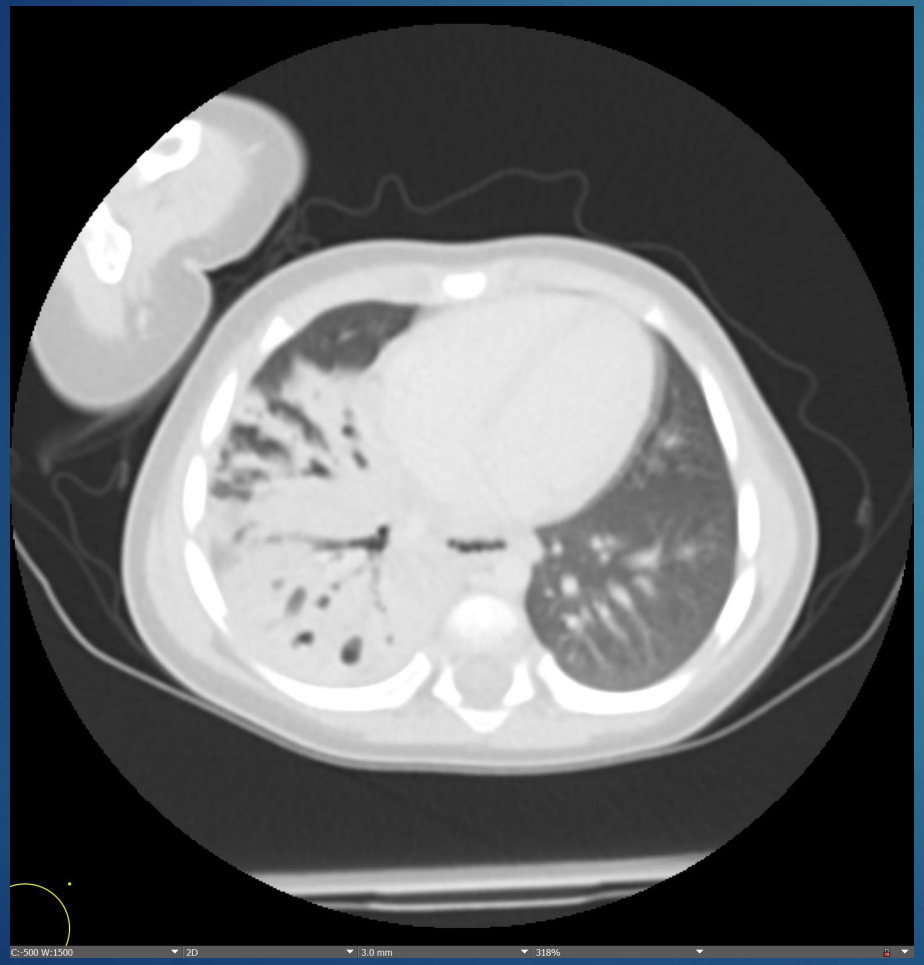


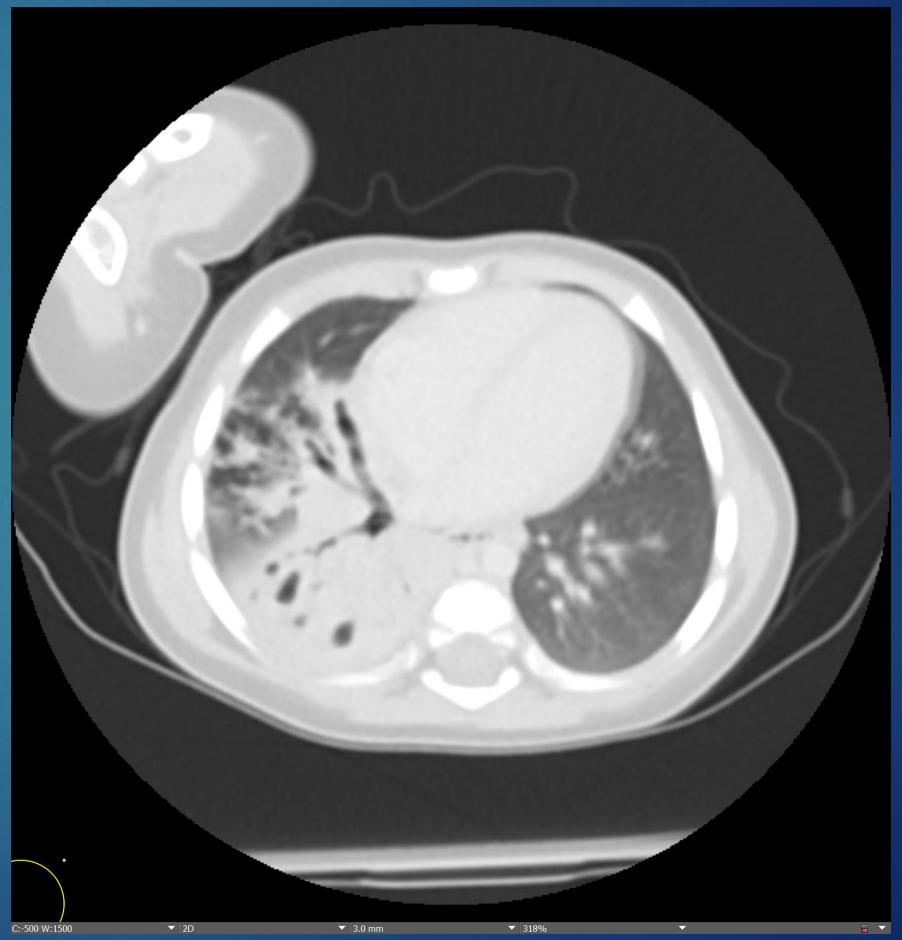
CT with IV Contrast





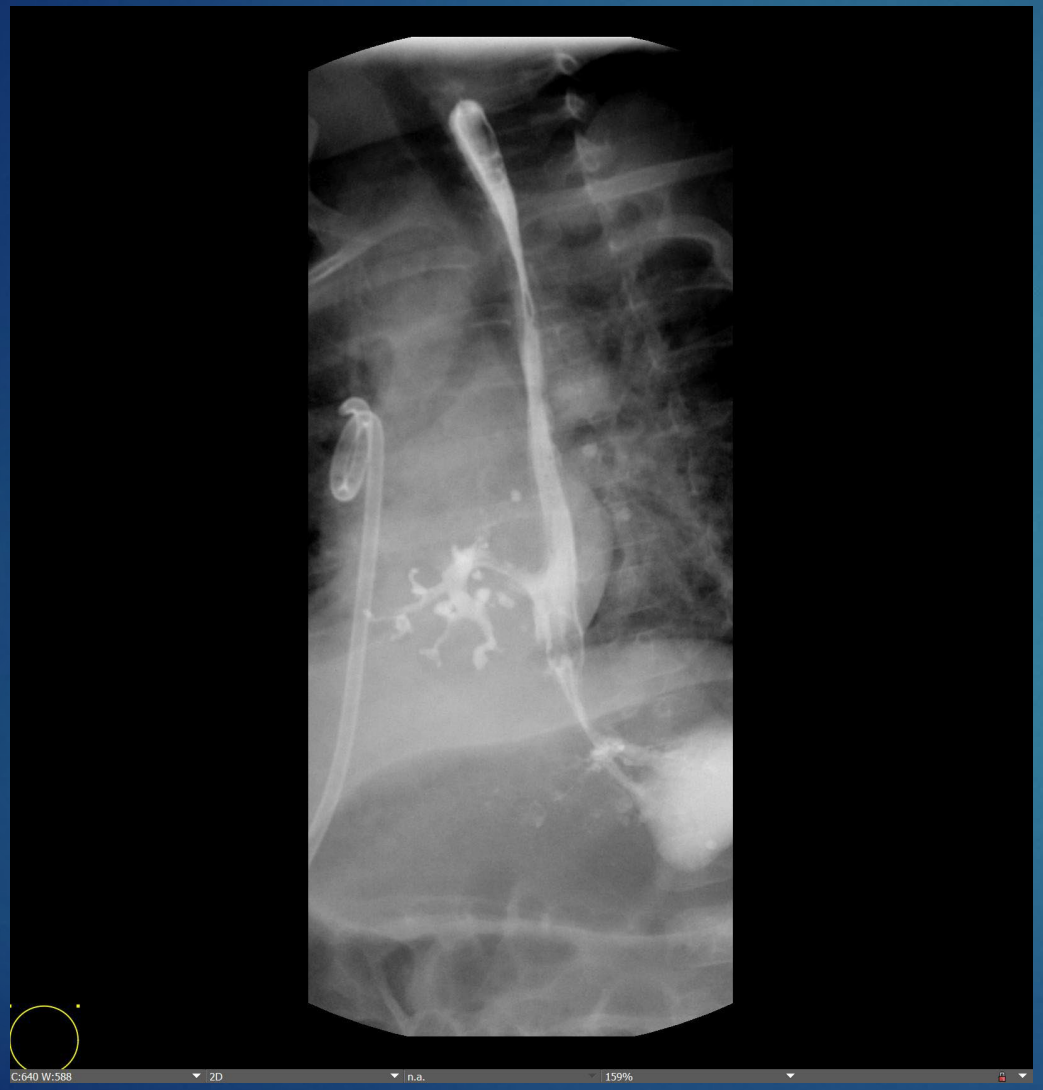
CT with IV Contrast

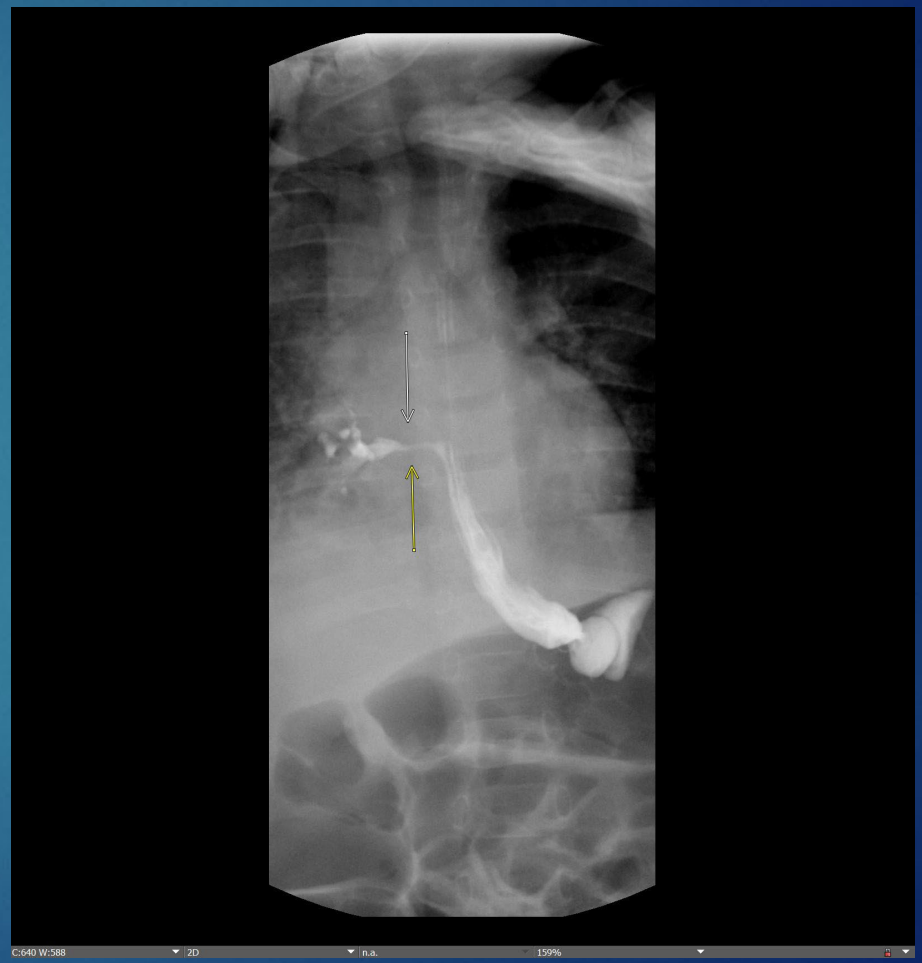




Chest CT

Esophagram





Esophageal Bronchus

- Congenital bronchopulmonary foregut malformation
- Rare – few reported cases
- Present with recurrent PNA and feeding difficulties
- Often on the right
- Tx = lobectomy

Abdomen/Pelvis

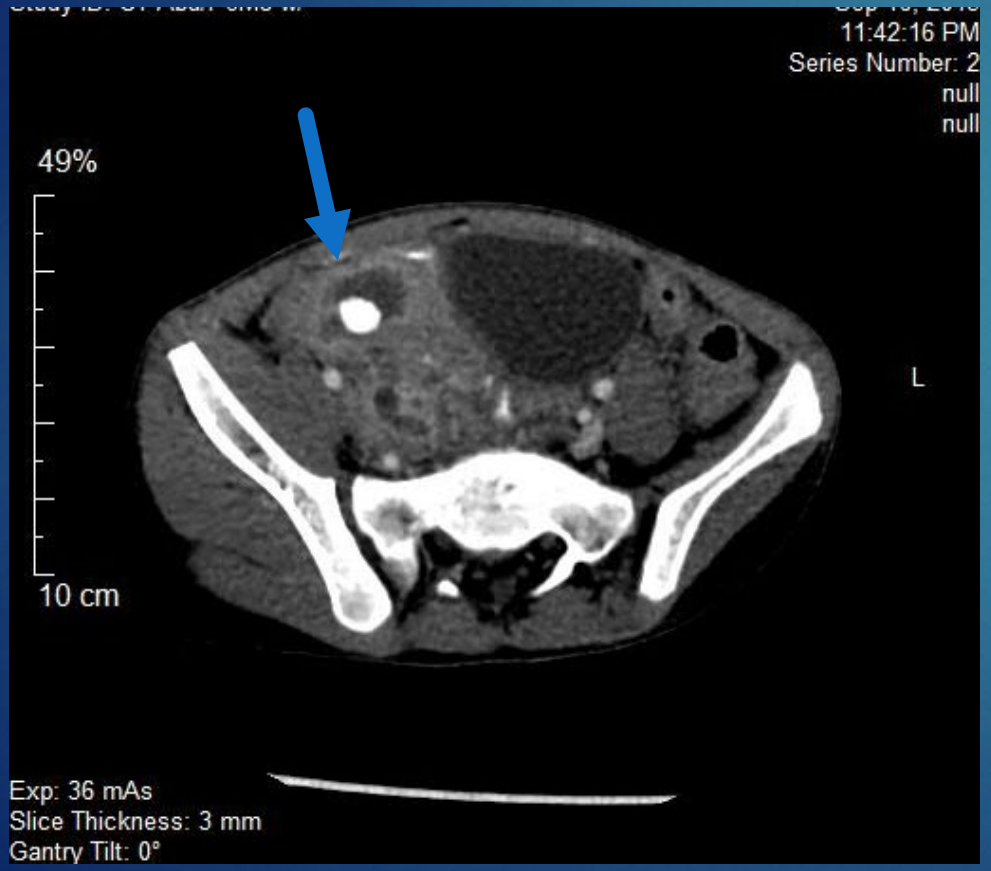
- Follow up of x ray or ultrasound abnormality
- IV Contrast, PO not required
- Can see stones in ureters; stones in the intrarenal collecting system may be more challenging

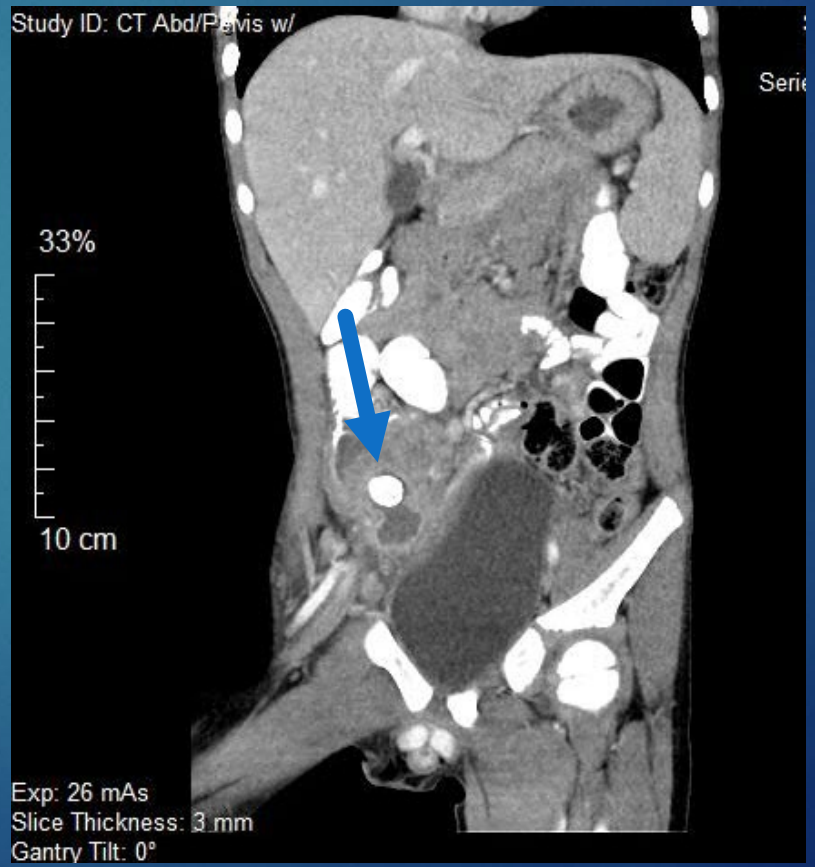
Acute Appendicitis

Variant 2: **Child. Suspected acute appendicitis, intermediate clinical risk. Initial imaging.**

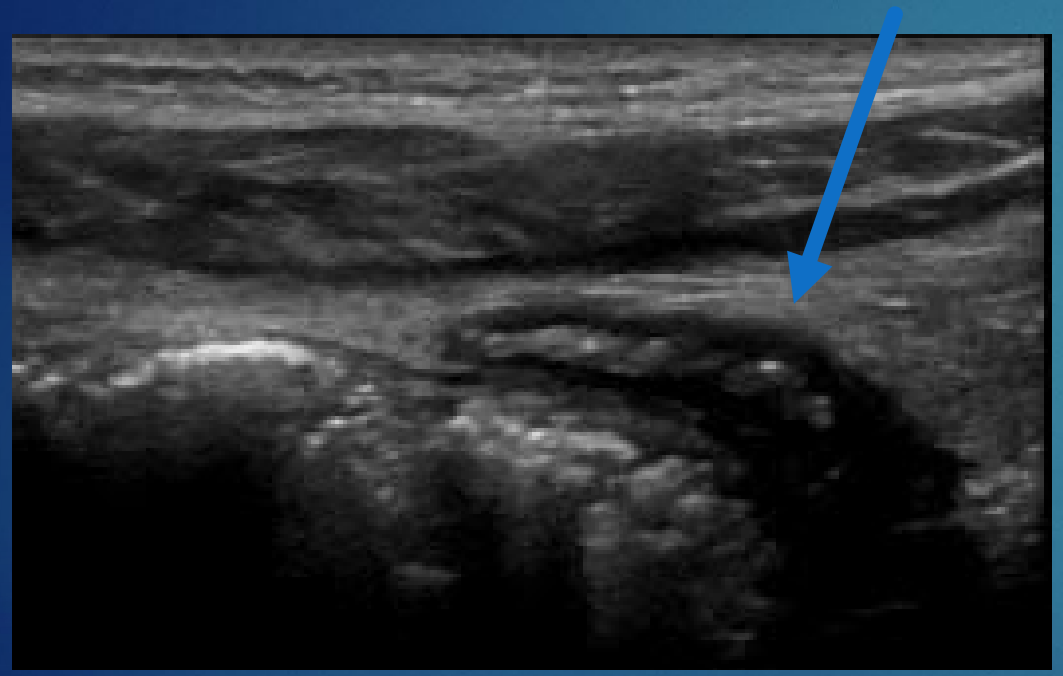
Procedure	Appropriateness Category	Relative Radiation Level
US abdomen RLQ	Usually Appropriate	O
US abdomen	Usually Appropriate	O
CT abdomen and pelvis with IV contrast	May Be Appropriate (Disagreement)	☢☢☢☢
CT abdomen and pelvis without IV contrast	May Be Appropriate (Disagreement)	☢☢☢☢
MRI abdomen and pelvis without and with IV contrast	May Be Appropriate (Disagreement)	O
MRI abdomen and pelvis without IV contrast	May Be Appropriate (Disagreement)	O
Radiography abdomen	May Be Appropriate (Disagreement)	☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢☢
US pelvis	Usually Not Appropriate	O

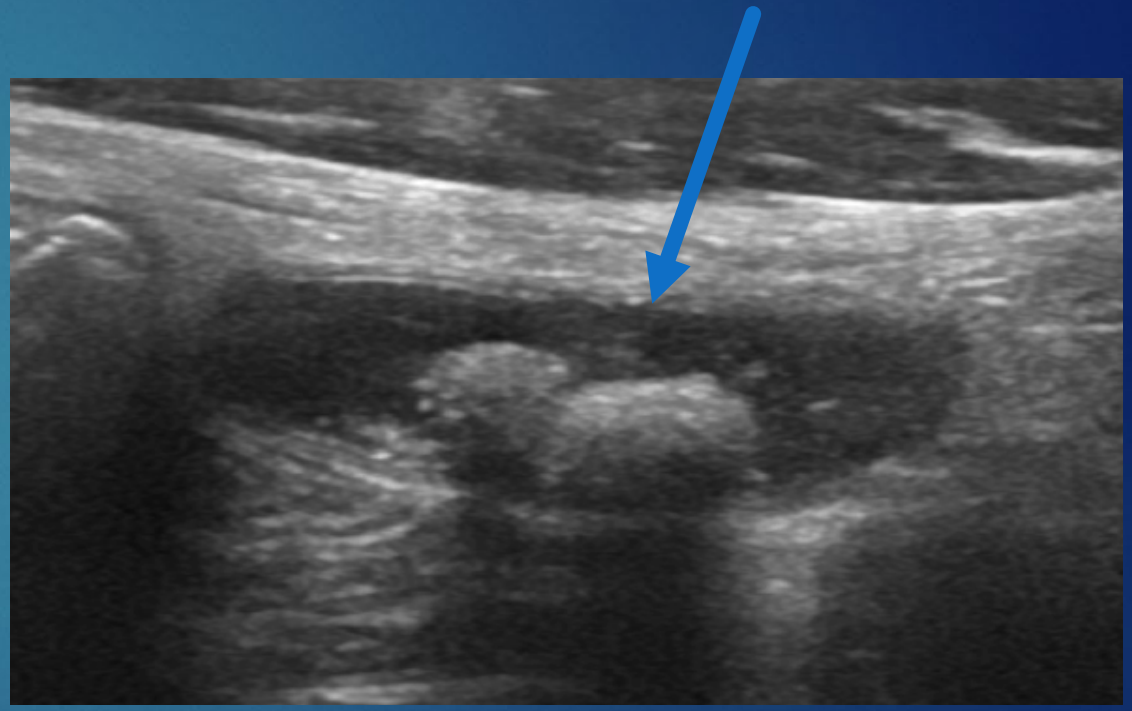
Acute Appendicitis





Acute appendicitis





Objectives

- History of CT
- How do we estimate radiation dose?
- What are the risks?
- Why CT?
- What can we do?

References

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- Brody, Alan S, Donald P. Frush, Walter Huda and Robert L. Brent. *Radiation Risk to Children From Computed Tomography*. Pediatrics 2007;120;677.
- Young, Carolyn, Cheng Xie, Catherine M. Owens. *Pediatric multi-detector row chest CT: what you really need to know*. Insights Imaging. 2012 June; 3(3): 229–246.

Questions?

- Allison Vitter
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- imagegently.org

- imagewisely.org

- acr.org/Clinical-Resources/ACR-Appropriateness-Criteria