



Pediatric CT: More than Just “Right-sizing” the Dose

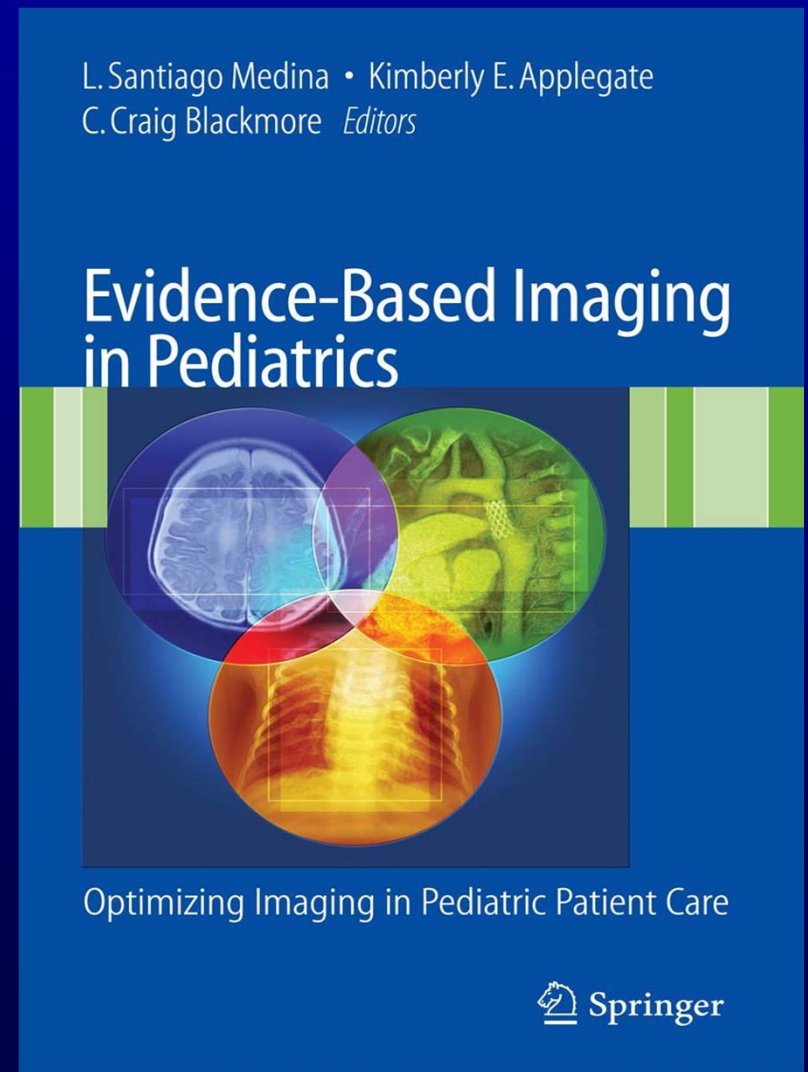
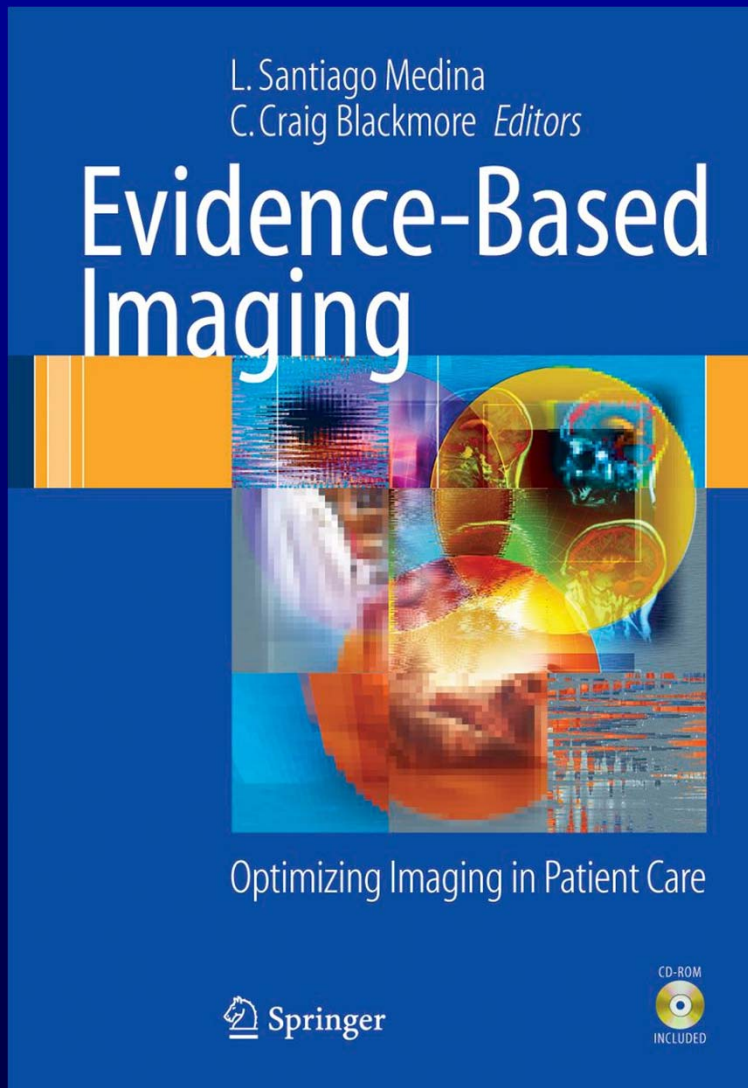
Kimberly E. Applegate, MD, MS
Emory University
Children’s Healthcare of Atlanta
(CHOA)





Disclosures

AIM (American Imaging Management) radiation protection advisory board and...



Objectives

- Patient and Family Preparation
- Specific Protocols
 - Oral Contrast and Sedation
 - Abdominal CT for Inflammatory Bowel Disease?
 - PET/CT
 - Pectus Excavatum
 - Fungal Infections
 - ECMO
- Acceptable Noise Levels in Pediatric CT





Why are Pediatric Protocols Different from Adult Protocols?

- Radiation dose is only one reason
- Safety issues (medication, sedation)
- Children do not cooperate until they understand and feel safe
- The pathology we look for is often different
 - Children have congenital anomalies and infections much more commonly than adults
 - When children have cancer, they have sarcomas whereas adults have carcinomas. These cancers occur in different places and act differently.



Preparing a Child and Their Family

- Remove fear, anxiety
- Explain the procedure
- The waiting room appearance matters and the literature (Image Gently, AAP)
- Reception staff and technologists **REALLY MATTER**
 - Minimize need for sedation
- Use distracters; rewards; social worker ('child life')
- Decorate the CT room and scanner





Preparation Techniques

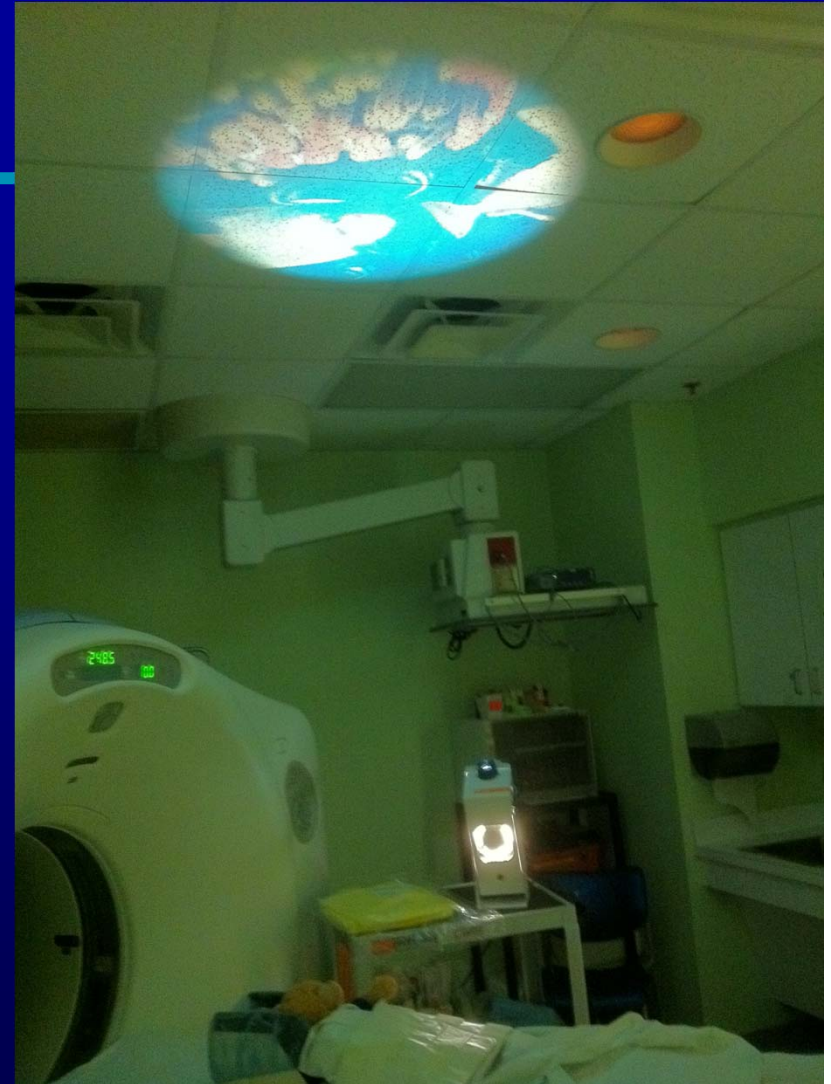
- Immobilize the child using foam pads and velcro straps
 - Age <3 yr vendor papoose
- Train CT techs and nurses to stay in the room for the contrast injection, talking to the child
- Single Phase CT is all you really need, REALLY





Sedation

- Typically: 6mo-4yr
 - Always try first without
 - Up to 50% need sedation
- Neonate: swaddle
- Non-contrast CT: intranasal versed first, then if needed propofol
- Infants/Children: IV propofol
 - Short-acting
 - Requires physician to admin





Sedation

- Moderate sedation performed by nurse
 - Versed
 - Fentanyl
 - Newer agents: dexmedetomidine
- Sedation vs oral contrast: must stop the oral contrast some time prior to the CT exam (CHOA policy is 60 min)





When is enteral contrast needed?

- Less frequent with improved technology:
 - Thinner reconstructed images
 - 3 plane reconstructed images
- Systematic review, Am J Surg 2005; Anderson BA:
 - No oral contrast abdominal CT is equivalent or better than oral contrast for diagnosis of appendicitis
- ASER member poll 2011: 50% no longer use bowel contrast



Drinking Contrast

- VoLumen 15 ml/kg up to 450 mls (1 bottle) over one hour
- 1 bottle Q20 min; scan at one hour
- Compare to routine oral contrast admin for abd/pelvis CT
- 200 ml Q30 min x 1 hour for age <7 yrs
- Ditto x 90 min for age 7-12 yrs
- Ditto x 2 hours for age > 12 yrs





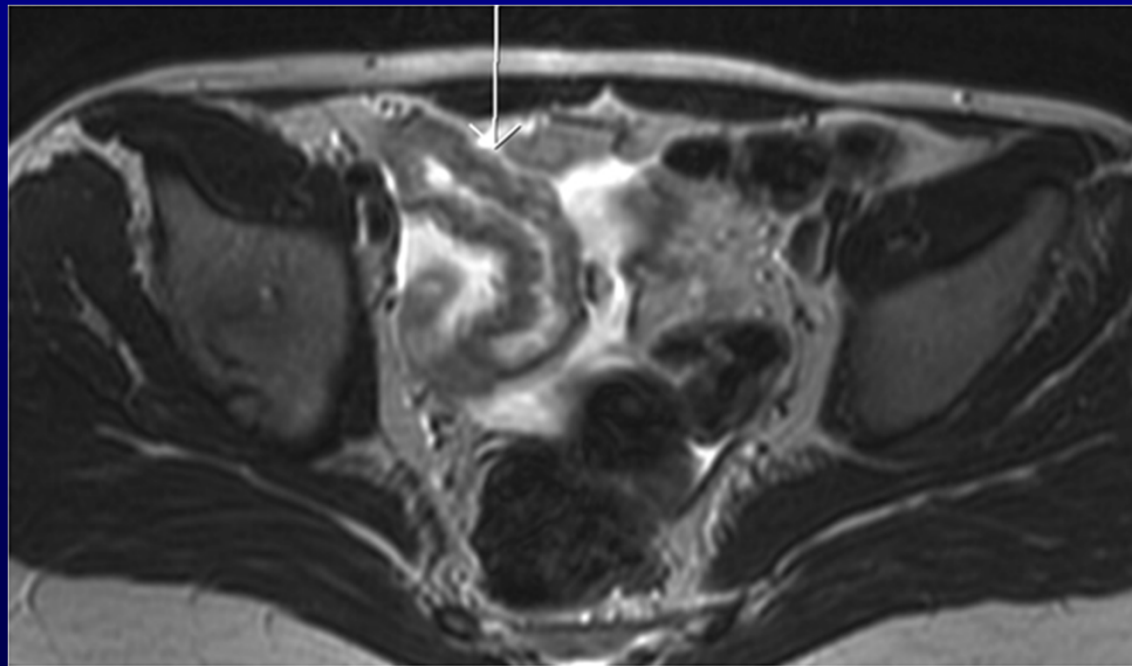
Encouraging the Child to Drink Oral Contrast

- Make it taste good and make it fun:
 - Sweeten it (it can never be too sweet)
 - Give them control: choice of flavors
 - Silly straws
 - Use their favorite cup from home
 - Refridge gatorade/mix
- NGT is the last resort

Crohn Disease Evaluation: MR vs CT

- MR or CT Enterography (imaging of the small bowel)

Abnormal Terminal Ileum



“Breath-hold” sequences on 3T: 20 minutes in adults,
45-60 min in children



“Medical radiation exposure in children with inflammatory bowel disease estimates high cumulative doses”

- 115 kids, 2002-2008
- Imaging for their dz only at one institution
 - CT > SBFT > all other imaging
- Median exposure 15.1 mSv CD vs 7.2 mSv UC
- 4.3 mSv/yr CD vs 3.4 mSv/yr UC

Inflamm Bowel Dis. 2011 Jan 13. [Epub ahead of print]
Sauer CG, Kugathasan S, Martin DR, Applegate KE.





MRE vs CTE

- MR Pros: no radiation—repeat customers; superior accuracy for perianal fistula
- CT pros: less expensive; faster so less need for sedation if movie goggles not available
 - IBD onset typically after age 5 years
- Sedation risk: lower than BEIR VII estimate of lifetime fatal cancer induction of 1:1,000--10,000 per abdominal CT in children (depending on technique)

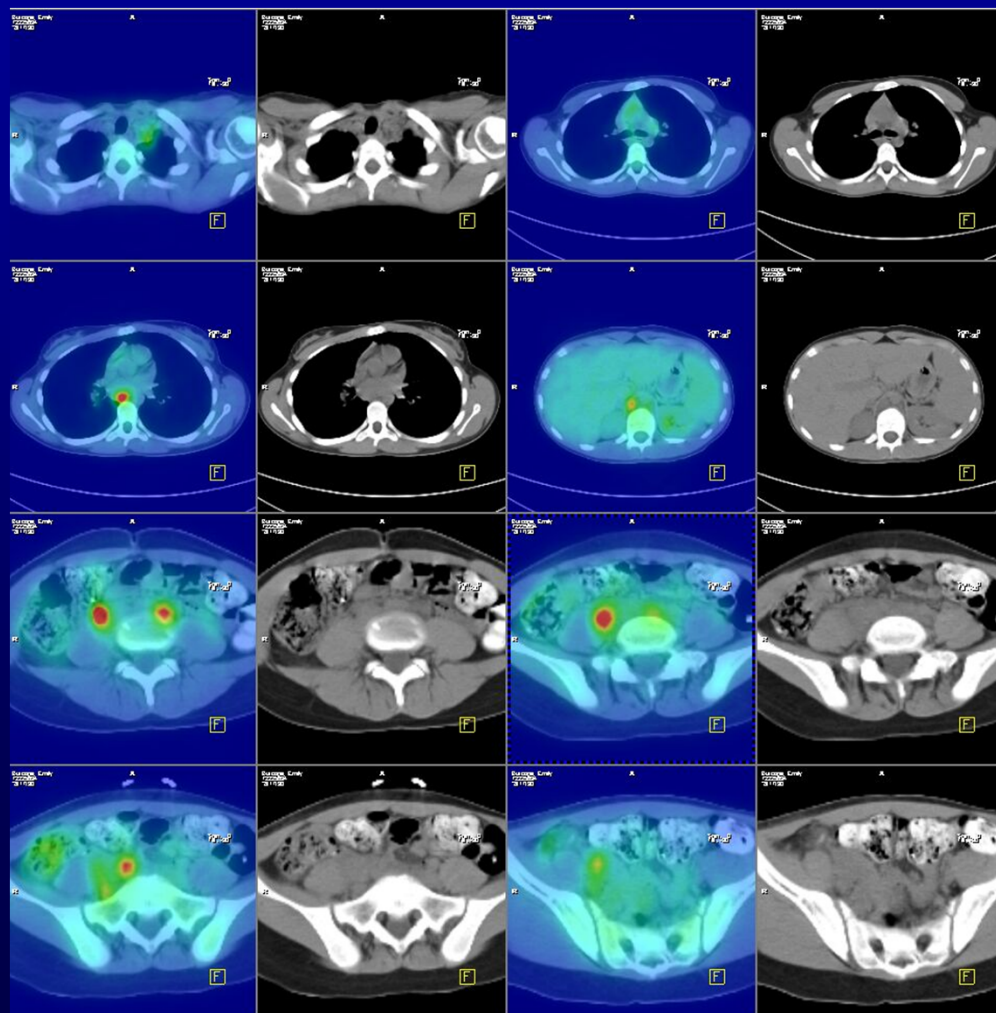


PET/CT in Children

- Increasing use with less clear outcomes compared to adults
- Use new Collaborative Consensus Guidelines for Administered Radiopharmaceutical Activities In Children and Adolescents
 - Society for Nuclear Medicine, Society for Pediatric Radiology, American College of Radiology (Image Gently)
- Continued occurrence of diagnostic CT day 1; PET/CT day 2: unnecessary radiation

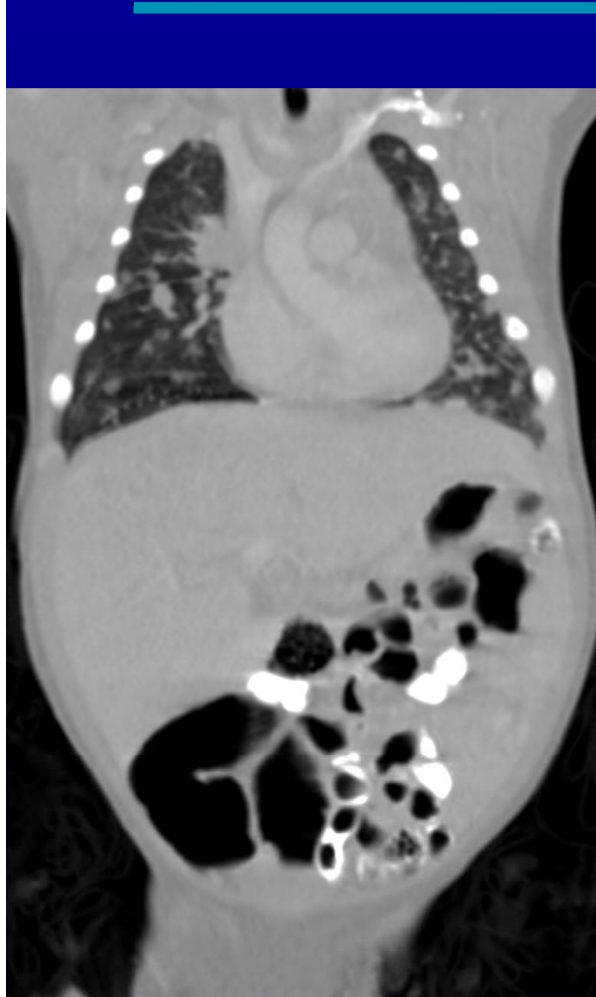
PET/CT of Lymphoma in 11 year old girl

- CT non-dx technique:
 - 30 mA
 - Skull to ankles
- Use very low dose technique
- Increased prevalence of bone pathology in children—image to ankles

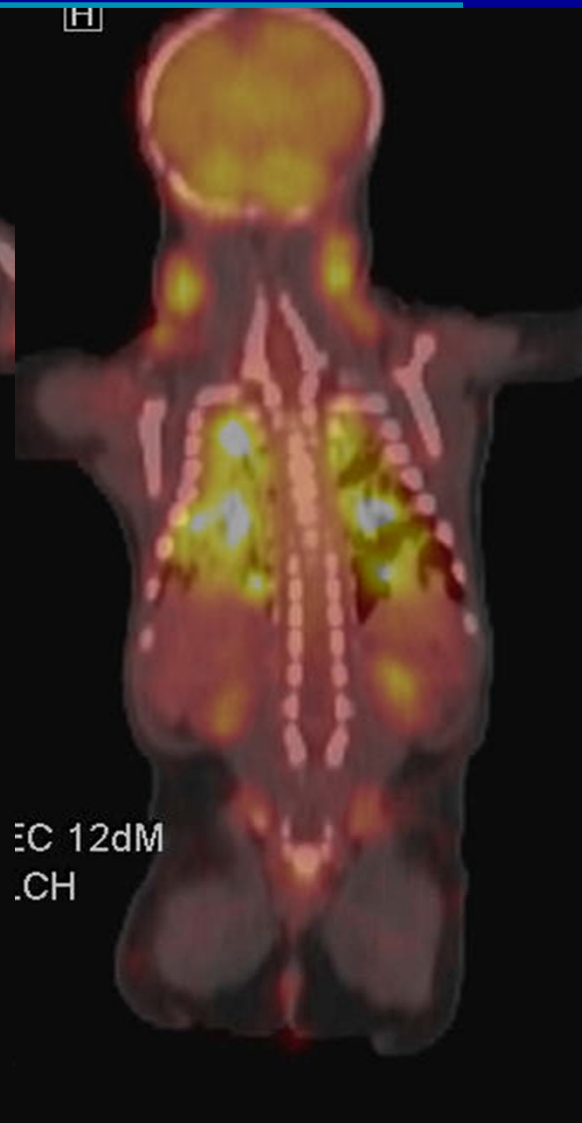
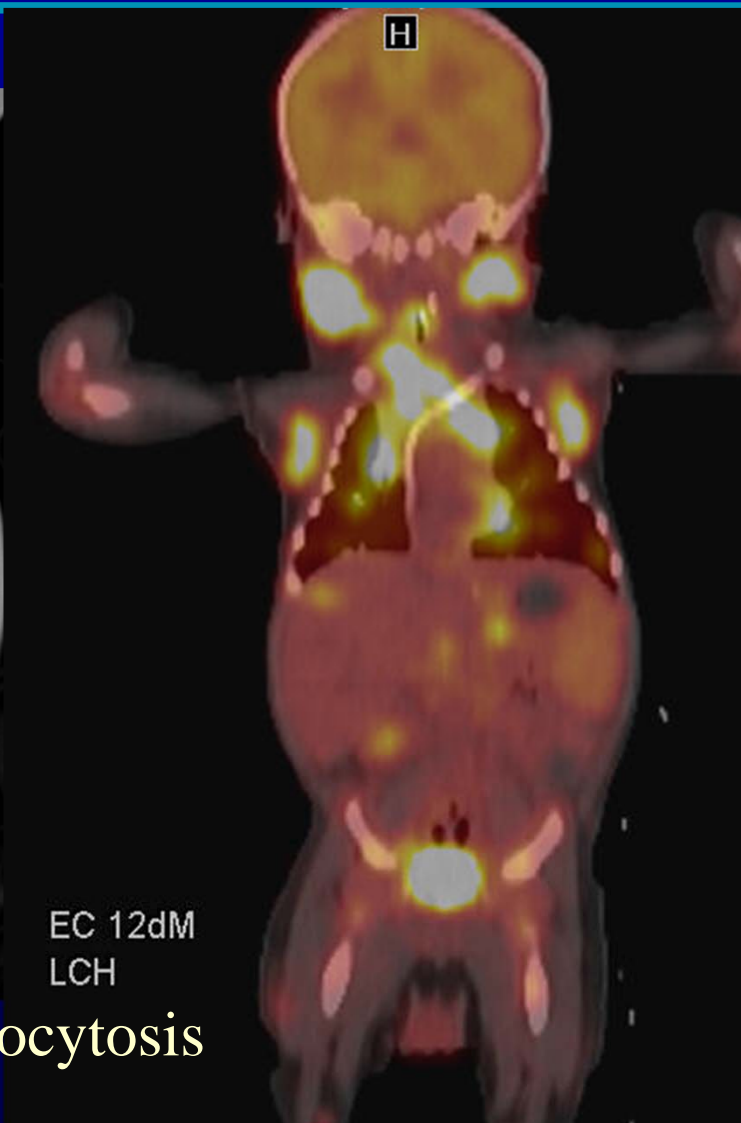




PET/CT: No Double CTs Please



Langerhans Cell Histiocytosis





Pectus Excavatum: Pre-operative Assessment

- Congenital abnormality of chest wall
- Can be present at birth but typically develops at puberty
- Many proposed techniques to decrease dose:
 - Low mA (20-30)
 - Decreased scan coverage AND low mAs
 - 2 view CXR
 - MRI



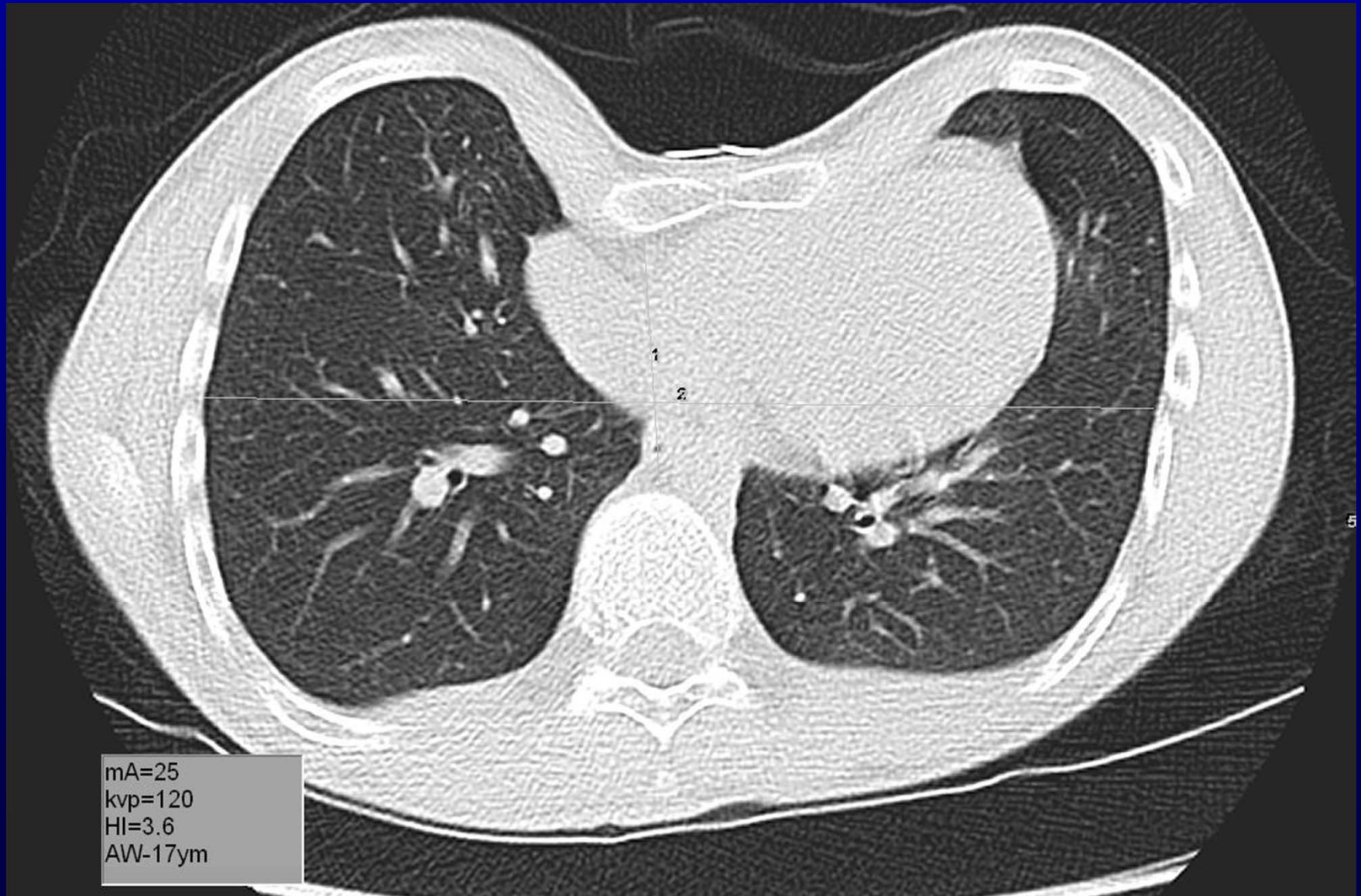
Pectus CT Protocol

- Tech marks deepest impression, scan coverage limited to area of interest
- 120 kVp
- 25 mA
- Rotation time 0.5 sec
- Acquisition 0.625mm
- Recon thickness 0.625mm
ax; 5mm--all 3 planes





Pectus CT Image at Deepest Impression



mA=25
kvp=120
HI=3.6
AW-17ym

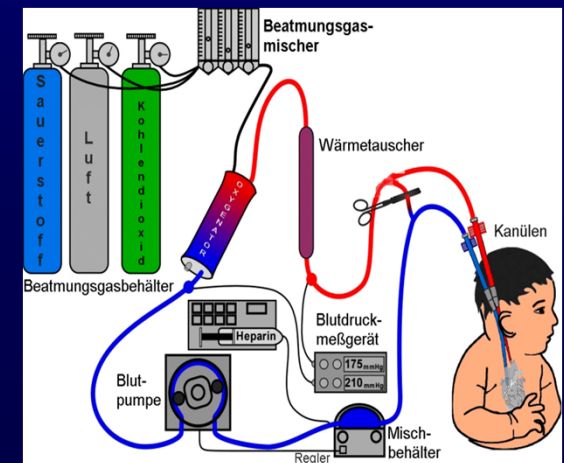


Fungal Infections

- Liver, Spleen, and Kidney microabscesses, e.g. candidiasis in immunocompromised patients, especially leukemic children
- Appearance: Tiny hypodense areas in solid organs (subtle)
- Suggest raising mAs for chest and abdomen CT protocols (or abdomen MRI)
 - mA 20% higher for all of our protocols

Extra-Corporeal Membrane Oxygenation

- ECMO; mechanical ventilation
- Very ill babies; intensive care unit
- Typically newborns with respiratory disease or congenital heart disease
- At risk for intraparenchymal bleeding...head CT
 - Portable head CT
- May also undergo portable CT of chest or abdomen if needed





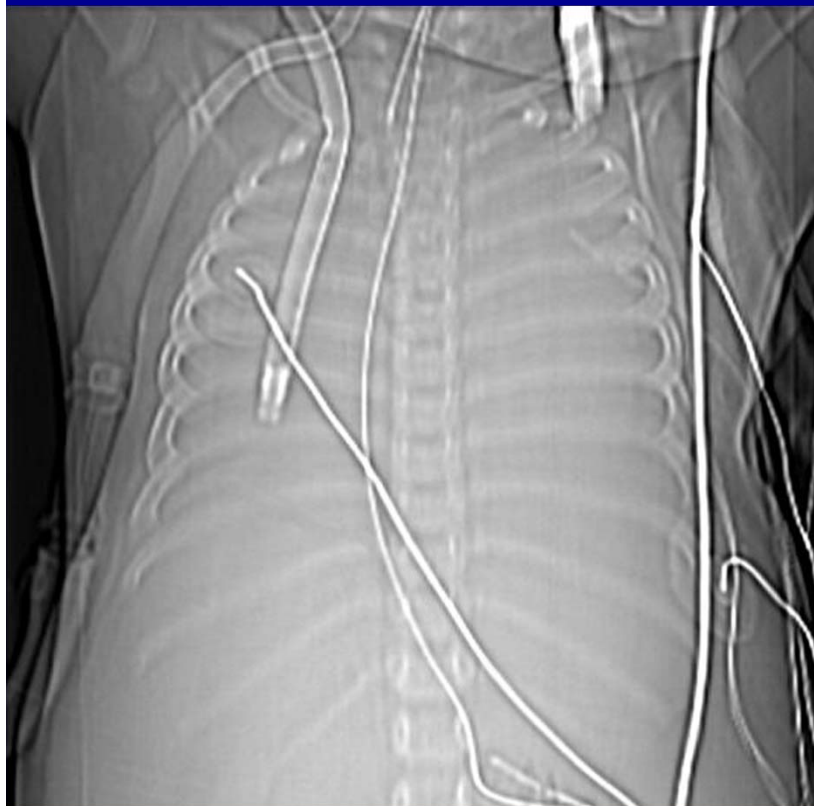
Portable CT of ECMO Babies



- Exposure doses similar to in department protocols (CTDI_v)
- Head CT image quality nearly equivalent
 - Acute bleed vs no bleed
- Except for contrast bolus timing: injection is typically via the ECMO infusion catheters and will have different timing compared to peripheral IV



Portable CT



1 yr girl pleural hemorrhage



Pediatric Noise Levels

- Matter of ongoing discussion
- Automatic exposure control systems are variable in “dialing down” exposures— too noisy? Not enough?
- Dose reduction is a significant goal, but not at the expense of diagnostic performance
- “Dialing down” iteratively (e.g start with Image Gently recommendations and slowly decrease over time), with ongoing consensus on image quality and diagnostic confidence feedback, can result in even lower doses



Pediatric Body CT Noise Levels

- CHOA experience: dose ‘moderates’, not liberals, not conservatives...
- Noise Index for head CT: 11
- NI for CT body angio exams: 22
- NI for CT routine body exams: 27.6
 - Auto-mA, with narrow ranges
 - Acq 0.625mm
 - Generally, recons at 2.5mm if less than age 4 yr and 5mm if 4 yr or older (wt based protocols)



Use of Iterative Reconstruction

- We use ASIR at low levels:
 - All Neuro CTs: 10%
 - All Body CTs: 20%
- Toronto Sick Kids: 50%



Pediatric CT and ACR Accreditation

- Noise levels for submission of images for CT accreditation set lower than current practice at some Children's Hospitals in USA
 - Informal Poll of Image Gently Steering Committee
- Is there an opportunity for applicants to submit images at their 'normal' protocols at which they interpret even if noisier images than ACR criteria?
- The 'standard' pediatric noise level is higher than adults but a moving target

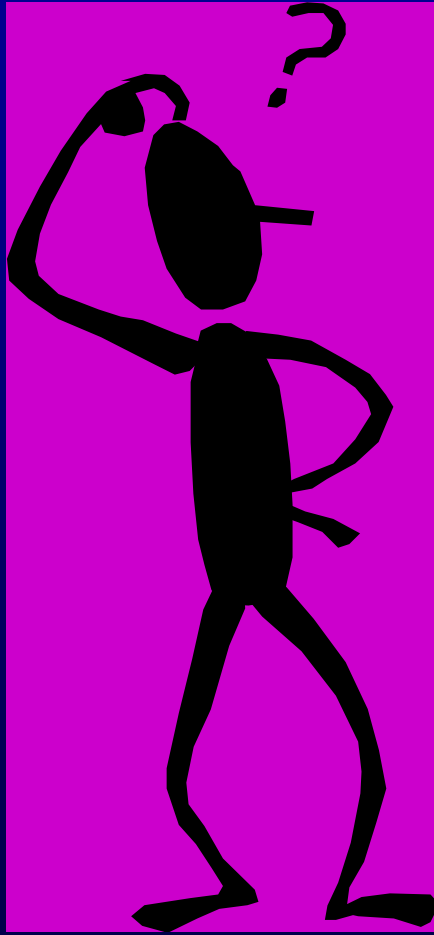


Summary

- Preparation of patients and family is critical to success of pediatric CT
 - Less sedation and optimal images
- Pediatric protocols differ from adult protocols in many ways
- Pediatric radiologists, in general body CT imaging, are comfortable with noisy images—trading image quality for lower dose
 - Understanding the clinical question that needs to be answered BEFORE the study is performed



Questions?



- keapple@emory.edu