

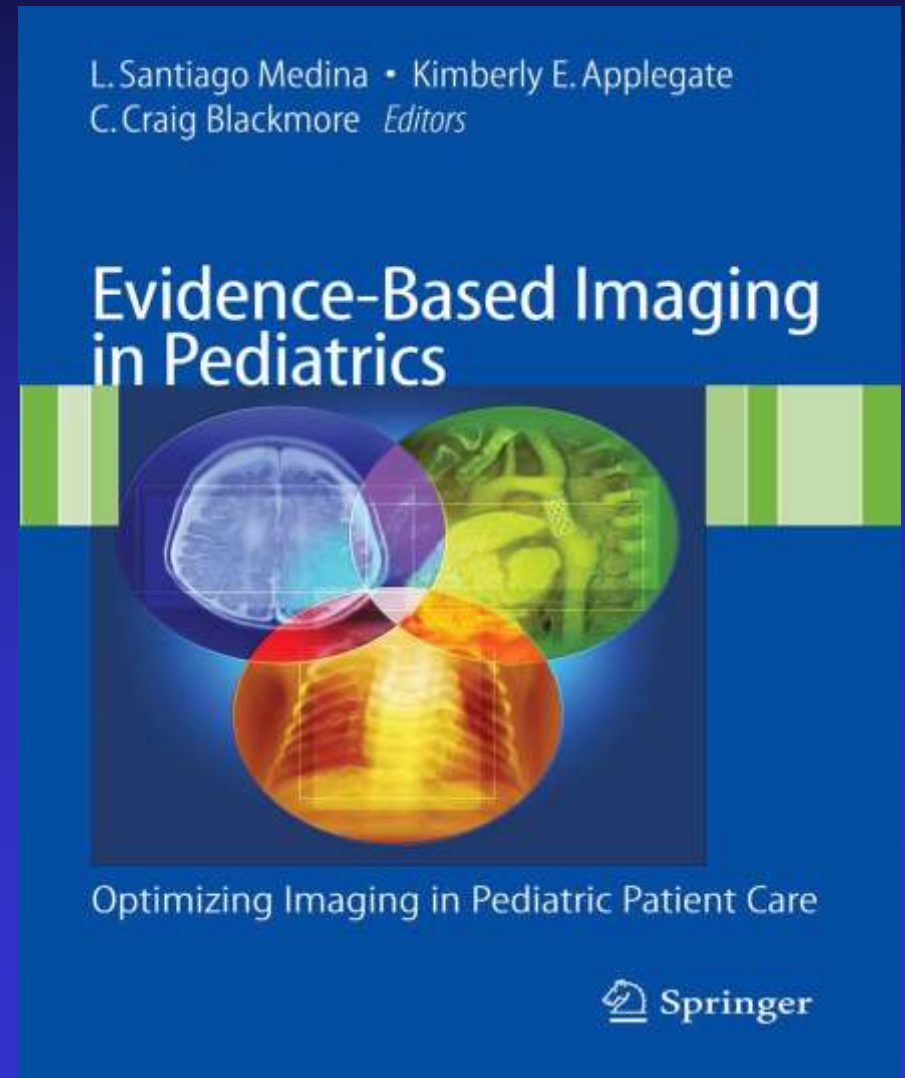
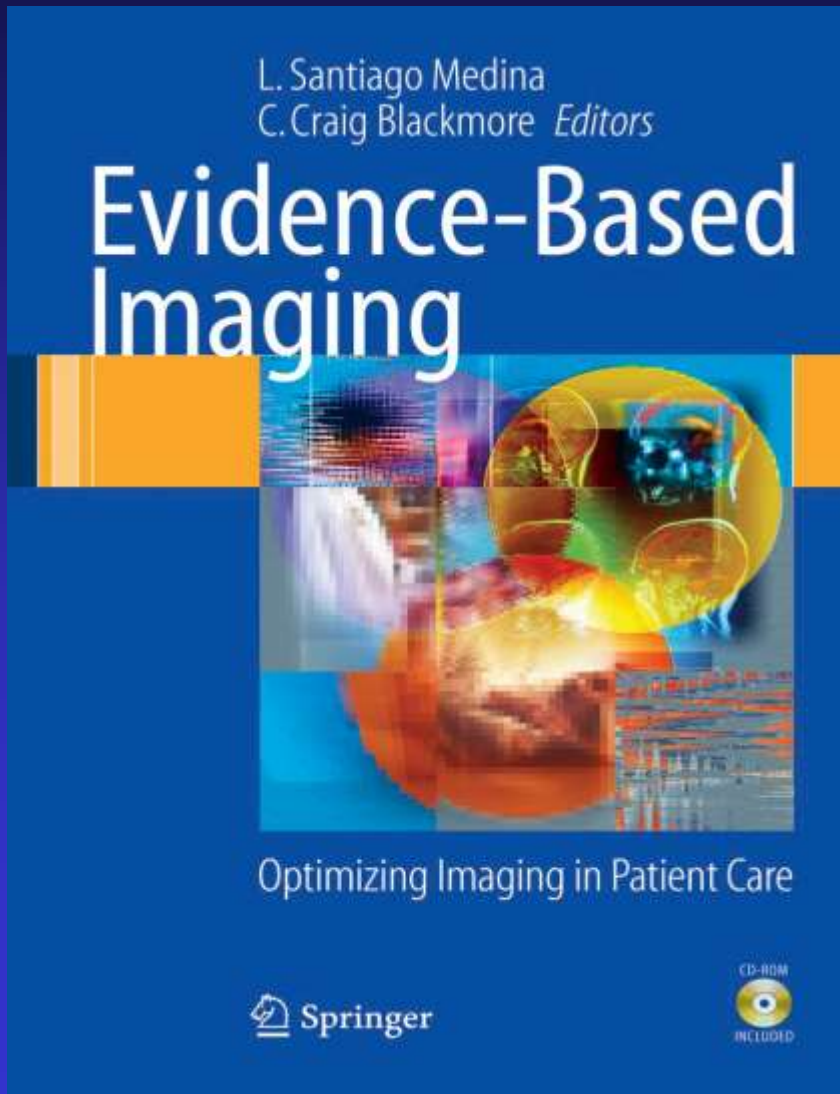
# Pediatric CT: More than Just “Right-sizing” the Dose

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Children’s Healthcare of Atlanta  
(CHOA)



# Financial Disclosures

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





# Media attention has heightened awareness



www.usatoday.com  
LATE SPORTS

**Let the hype begin**

**Super Bowl**

Clock is ticking toward Sunday. Full report, 1-4C  
► 10 years ago, war was on our minds, 1C  
► Coming Friday: Bonus Section

THE NATION'S NEWSPAPER

**USA TODAY**

NO. 1 IN THE USA

**'Gladiator' top film at Golden Glo**

Julia Roberts takes best actress for *E. Brockovich*; George Clooney gets come nod; Kate Hudson for *Almost Famous*  
► The red carpet,

Monday, January 22, 2001

**Newsline**

**CT scans in children linked to cancer later**

By Steve Sternberg  
USA TODAY

Each year, about 1.6 million children in the USA get CT scans to the head and abdomen — and about 1,500 of those will die later in life of radiation-induced cancer, according to research out today.

What's more, CT or computed tomography scans given to kids are typically calibrated for adults, so children absorb two to six times the radiation needed to produce clear images, a second study shows. These doses are "way bigger than the sorts of doses that people at Three Mile Island were getting,"

David Brenner of Columbia University says. "Most people got a tenth or a hundredth of the dose of a CT."

Both studies appear in February's *American Journal of Roentgenology*, the nation's leading radiology journal. The first, by Brenner and colleagues, is the first to estimate the risks of "radiation-induced fatal cancer" from pediatric CT scans. Until a decade ago, CT scans took too long to perform on children without giving them anesthesia to keep them still. Today's scanners spiral around the patient in seconds, providing cross sections, or "slices," of anatomy.

Doctors use CT scans on children to search for cancers and ailments such as appendicitis and kidney stones.

"There's a huge number of people who don't just receive one scan," says Fred Mettler of the University of New Mexico, noting that CT scans are used for diagnosis and to plan and evaluate treatment. "The breast dose from a CT scan of the chest is somewhere between 10 and 20 mammograms. You'd want to think long and hard about giving your young daughter 10 to 20 mammograms unless she really needs it."

Mettler recently published a study showing that 11% of the CT scans at his center are done in children under 15, and they get 70% of the total radiation dose given to patients. Children have more rapidly dividing cells than adults, which are more susceptible to radiation damage. Children also will live long enough for cancers to develop.

Researchers led by Lane Donnelly at Cincinnati's Children's Hospital found that children often get radiation doses six times higher than necessary. Cutting the adult dose in half would yield a clear image and cut the risk a like amount, Brenner says. "Radiologists genuinely believe the risks are small," he says. "I suspect they've never been confronted with numbers like this."

CT criticized for excessive radiation dose since 2001

# Collaboration





# One size does not fit all...

There's no question — CT helps us save kids' lives!

But...When we image, radiation matters!

Children are more sensitive to radiation.

What we do now lasts their lifetime.

So, when we image, let's image gently.

More is often not better.

When CT is the right thing to do:

- Child size the kVp and mA
- One scan (single phase) is often enough
- Scan only the indicated area

A timely message from the Alliance for Radiation Safety in Pediatric Imaging.



image  
gently<sup>SM</sup>



Visit [www.imagegently.org](http://www.imagegently.org).

Made possible by an unrestricted educational grant from GE Healthcare



# Objective

- Discuss Top Ten Things YOU Can Do to Improve CT Dose Management
  - Team Effort is the key
  - Image Gently: Ten Steps You Can Take to Optimize Image Quality and Lower CT Dose for Pediatric Patients.  
Strauss K et al. AJR 2010;194:868-873





# Number 1: Increase Awareness and Understanding of CT Dose Issues Among RTs

- Until 2007, physics of CT equipment not in RT curriculum
  - Provide further training; IG online modules
  - ASRT CT Basics course
- CT technologists at minimum should be ARRT registered
- Encourage techs to become ARRT CT certified
- Encourage techs to take the Image Gently pledge and to take free CE online CT courses on Image Gently web





**Join with us.**

**Take the  
image gently pledge.**

**Today.**





# More 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 BIG 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



Courtesy of Renee Ahmed

# 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



Courtesy of Renee Ahmed

# 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 informal member poll 2011: 50% no longer use bowel contrast

# Drinking Contrast

- VoLumen 15 ml/kg up to 450 mls (1 bottle) over one hour
- Teen: 1 bottle Q20 min; scan at one hour
- Compare to routine oral contrast:
- 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
- Neonate: 60ml ➡ 16 yrs: 960ml



# 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

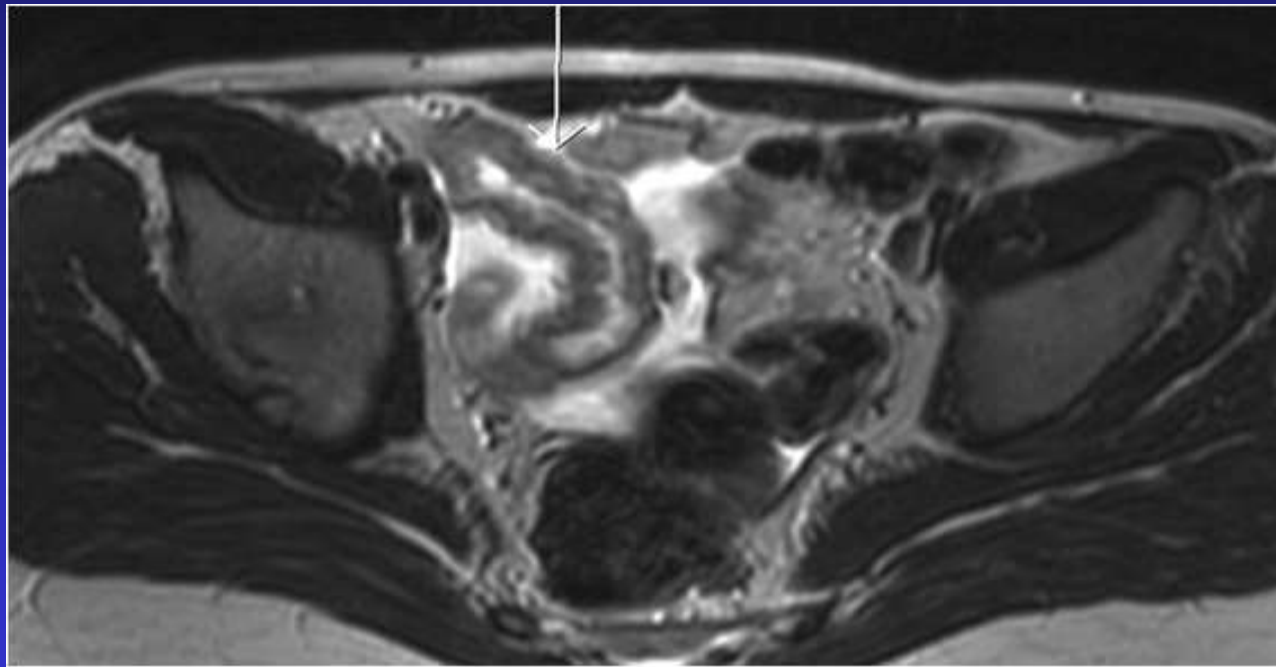




# Crohn Disease Evaluation: MR vs CT

- 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]  
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)

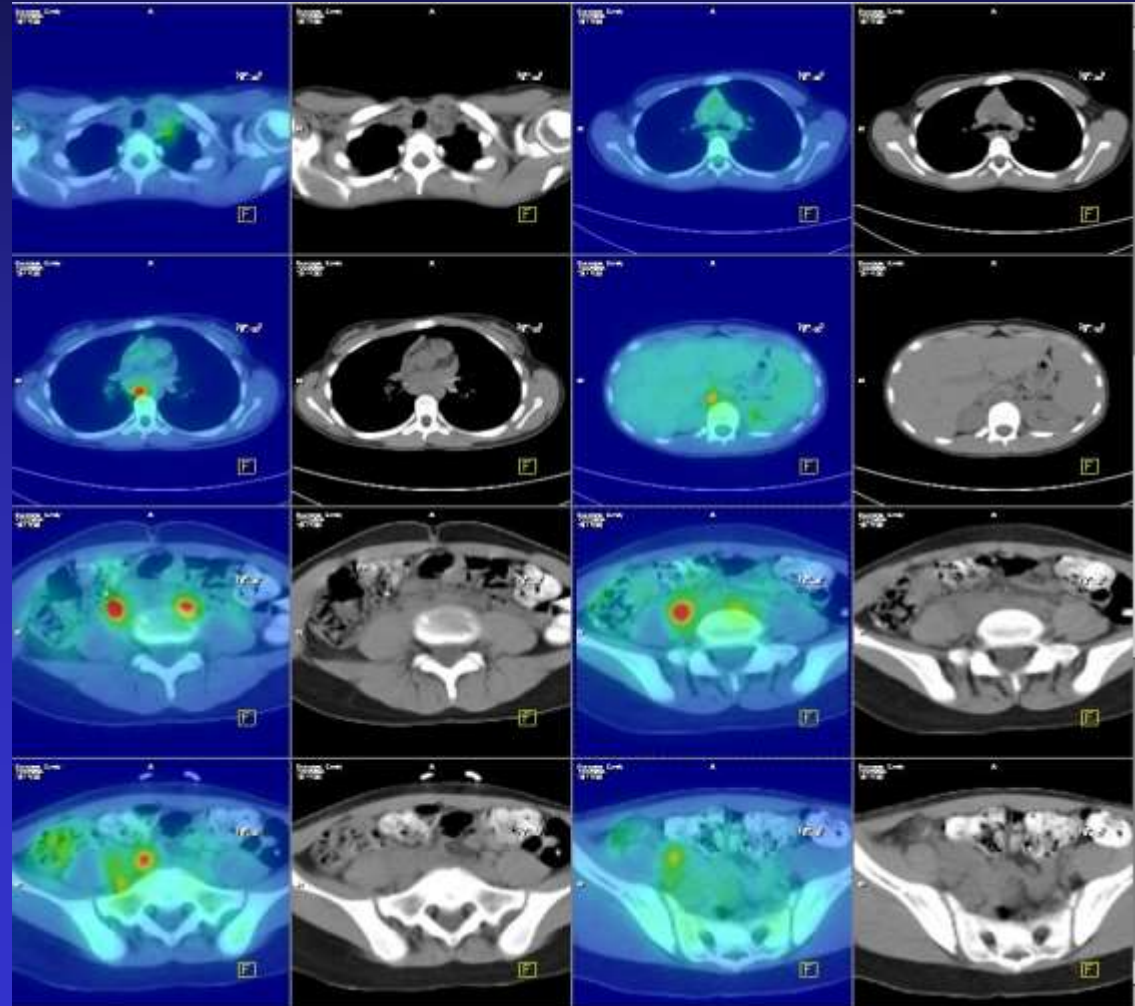


# PET/CT in Children

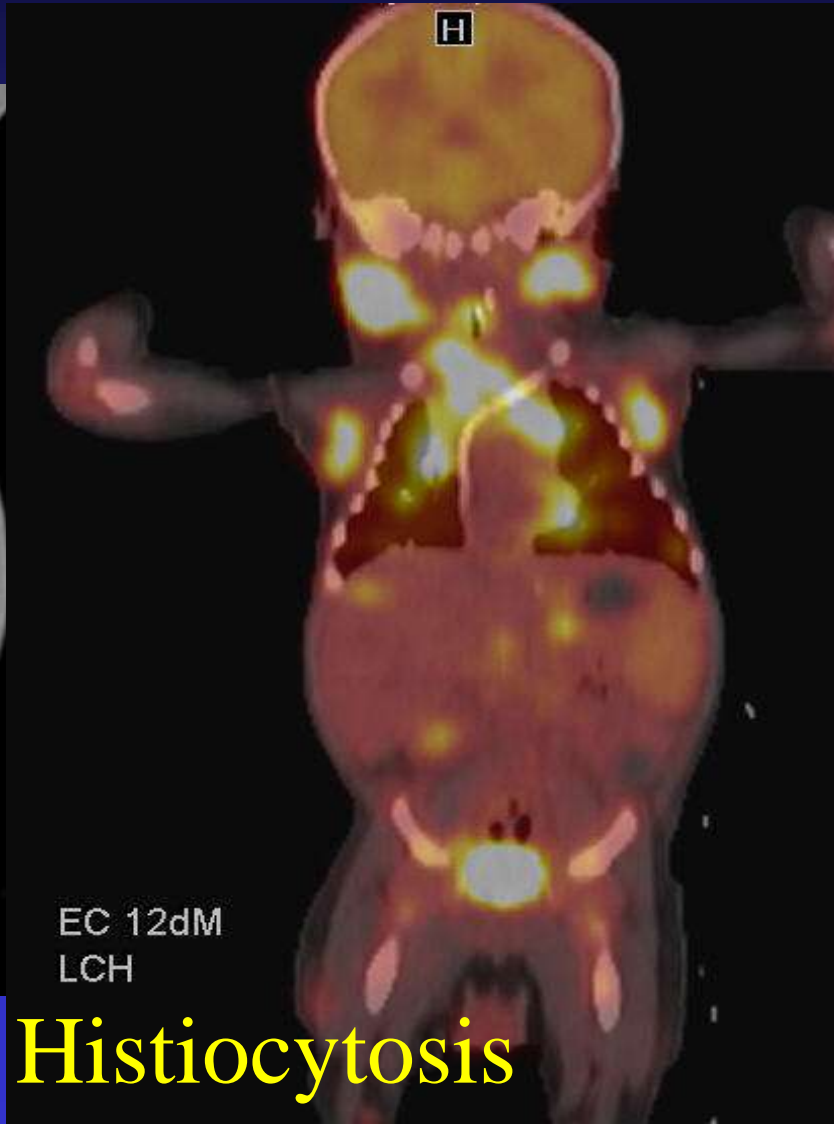
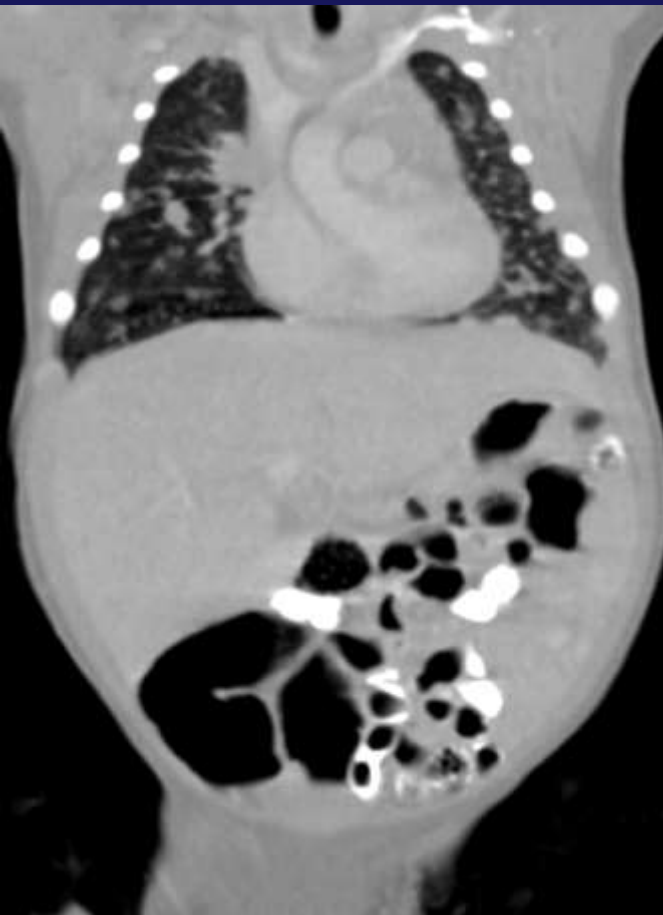
- Increasing use with less clear outcomes compared to adults
- Use new Collaborative Consensus Guidelines for Administered Radiopharmaceutical Activities In Children and Adolescents
  - Society for Nuclear Medicine, Society for Pediatric Radiology, American College of Radiology (Image Gently)
- Continued 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

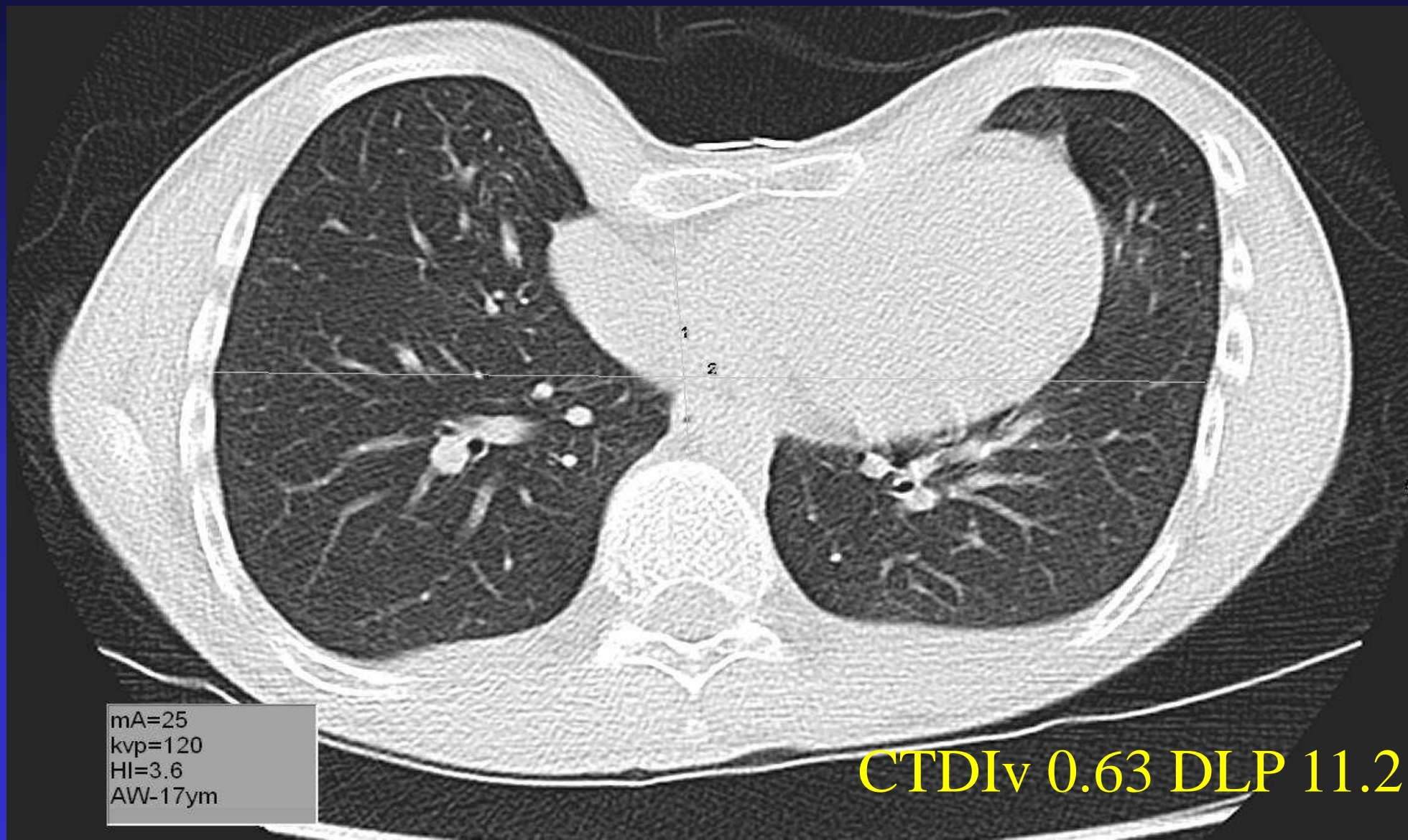
- Congenital abnormality of chest wall
- Can be present at birth but typically develops at puberty
- Many proposed techniques to decrease dose:
  - Low mA (20-30)
  - Decreased scan coverage AND low mAs
  - 2 view CXR
  - MRI

# Pectus CT Protocol

- Tech marks deepest impression, scan coverage limited to area of interest
- 100 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



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

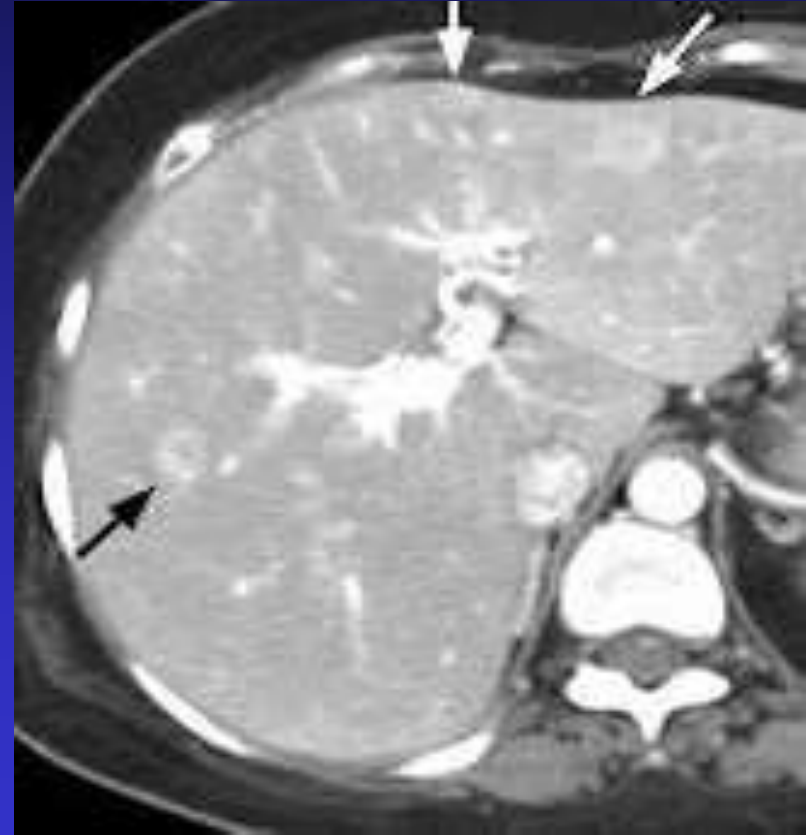
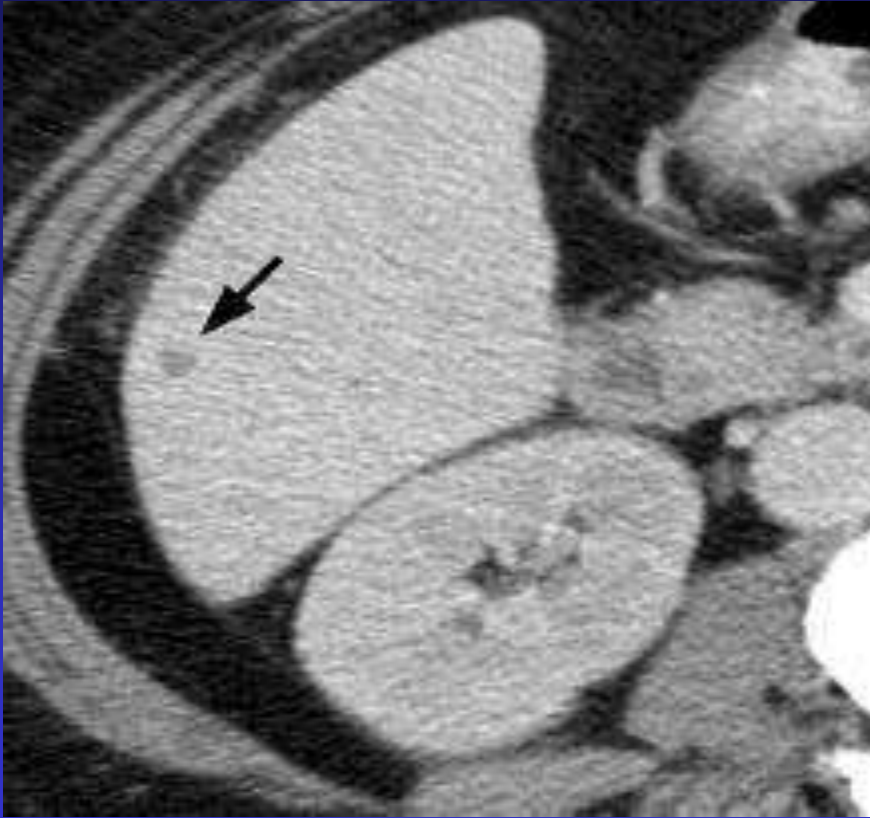
CTDI<sub>v</sub> 0.63 DLP 11.2

# 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

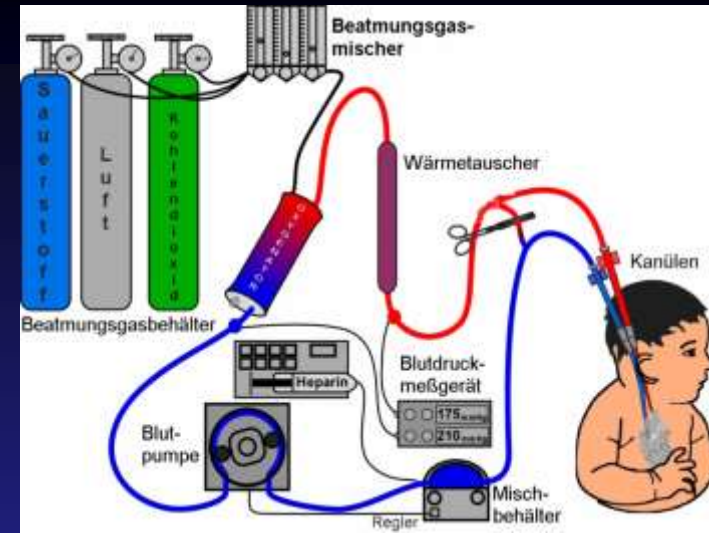


# CT of Candidiasis in two immunocompromised patients



# 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

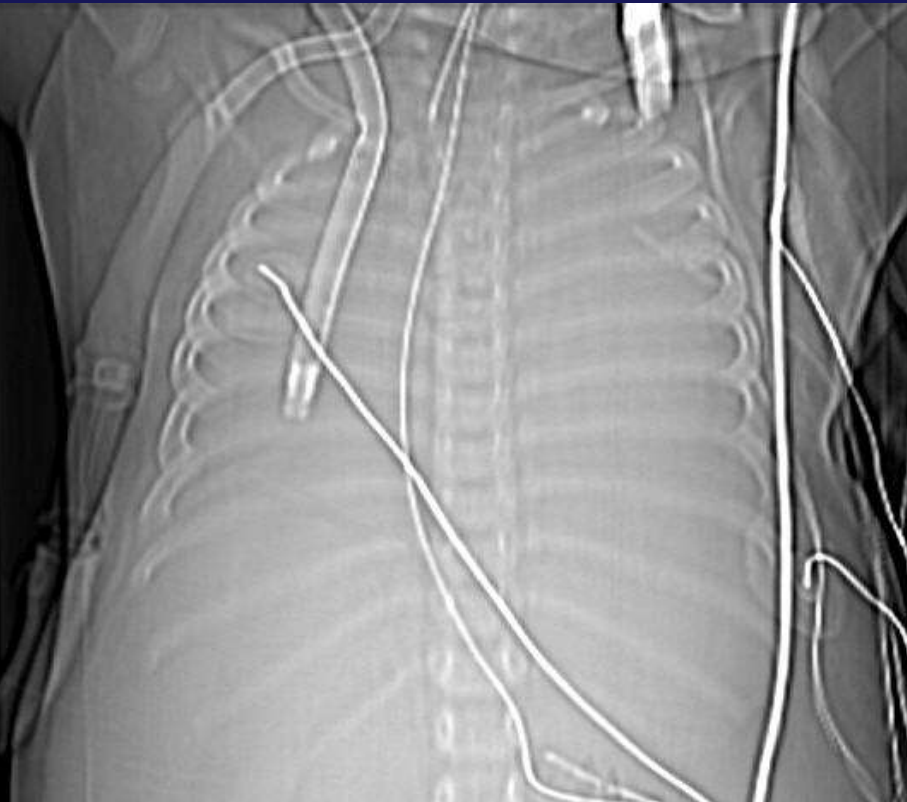


# Portable CT of ECMO Babies



- Exposure doses similar to in department protocols (CTDI<sub>v</sub>)
- 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 with 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:
  - Adult 3.8 vs Pediatric 2.5 (CTDI<sub>v</sub> 17 for peds head)
- NI for CT routine body CT:
  - Adult 15 vs Pediatric 27.6
  - Renal Stone Protocol: younger 60mA; older 100 mA
  - 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

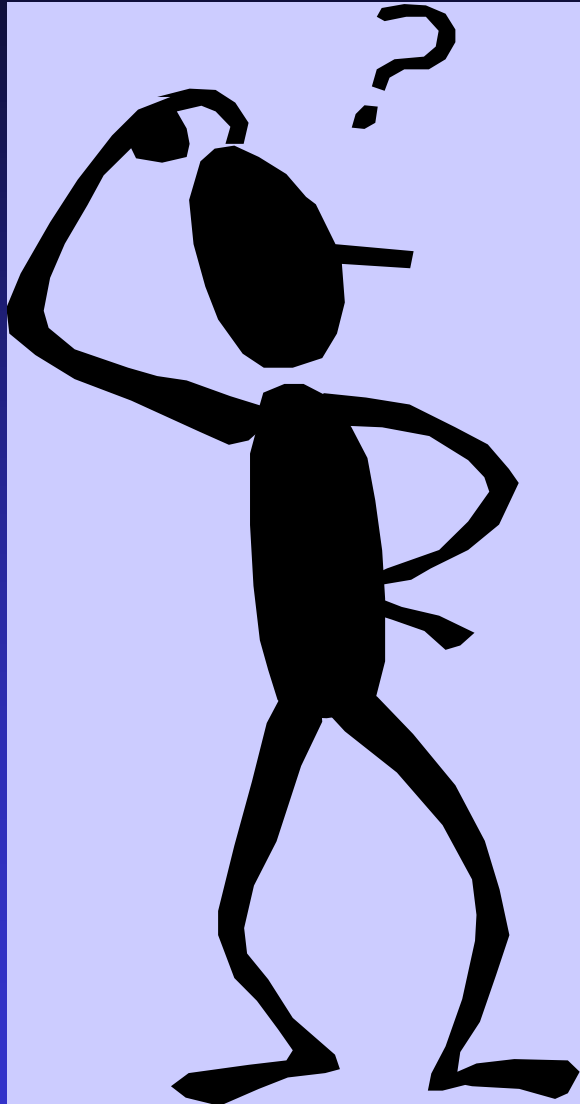
- Noise levels for submission of images for CT accreditation set lower than current practice at some Children's Hospitals in USA
  - Informal Poll of Image Gently Steering Committee
- Is there an opportunity for applicants to submit images at their 'normal' protocols at which they interpret even if noisier 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 (and pathology) 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](mailto:keapple@emory.edu)



# Can CT use be reduced? Clinical Decision Rules

Some common CT scenarios where there is evidence that CT use could be reduced:

- CT for minor head trauma (observation)
- CT for VP shunt malfunction (fast MRI)
- CT for renal colic (U/A; US)
- CT for abdominal pain/appendicitis (US, MRI)
- CT for blunt abdominal and chest trauma (FAST\*, observation)

\*Focused Assessment with Sonography in Trauma



# Examples

- CATCH clinical prediction rule: high sensitivity, specificity for head CT need in minor pediatric head trauma
- Chest CT in blunt pediatric trauma
  - J Trauma 2009. TA Markel et al.
  - Significant drop in CXR use with sig increase in CT use
  - CXR identified all severe abnormalities
- Head CT for VP shunt malfunction evaluation
  - AJNR 2008. Udayasankar UK et al.
  - Same kVp, lowered mA from 220 to 80 without significant change in image quality

# Summary: Improving CT Dose Management

- It is a team effort
- The medical physicist, technologist, and radiologist must work together to:
  - Advocate for patients to referring providers
  - Optimize image quality
- Decision support for CPOE systems will bring needed evidence to the referring provider to allow justification of CT imaging