The Pediatric Radiologist

Tailoring CT Protocols to the Patient's Age, Size, and Clinical Scenario

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Image Gently is…

An Education, Awareness, and Advocacy Campaign

The mission of the Image Gently Alliance is, through advocacy, to improve safe and effective imaging care of children worldwide.

The Message:

- Justification: Do the study if it is the right one
- **Optimization: Do the study right**
- 'Dose Limits' (audits, some sort of regional, national DRLs): Make sure the right dose was used

Agenda-The Progress is Real

- Pediatric CT dose reduction
  - Role of all stakeholders, vendors
  - One moment on AAPM TG 204, 220, 293
  - One moment on dual energy CT
- DRLs—European, regional, and country
- Dose registries: eg, ACR DIR and what we are learning
- AND-- 10 STEPS toward optimization

U.S. Diagnostic Reference Levels and Achievable Doses for 10 Adult CT Exams

- 310,000+ exams
- 46% community hospitals
- >50% facilities did small volumes (<500/yr)
- Comparable to DRLs from 8 countries
- U.S. Diagnostic Reference Levels and Achievable Doses for 10 Adult **CT** Examinations. Kanal KM, Butler PF, Sengupta D, Bhargavan-Chatfield M, Coombs LP, Morin RL. Radiology. 2017 Feb 21 EPUB

Examples

CTDIv	AD(50th%)	DRL(75th%)
• Head w/o	49	57
• Chest w/	10	13
• A/P	12	15

- Pediatric data pending publication

Image Gently CT Techniques

Pediatr Radiol
DOI 10.1007/s00247-014-3088-8

IMAGE GENTLY ALARA CT SUMMIT: HOW TO USE NEW CT TECHNOLOGIES FOR CHILDREN

Developing patient-specific dose protocols for a CT scanner and exam using diagnostic reference levels

Keith J. Strauss

AAPM TG204 (2011) with ICRU
AAPM TG220 (WATER CORRECTION)
AAPM TG293 (HEAD) pending

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.

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

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

Objective 2

- Discuss Top Ten Things Providers Can Do to Improve CT Dose Management
  - Team Effort
  - 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

We can't measure patient dose

"The determination of ionizing radiation dose to a living human from an x-ray exam is very complex….."

At best, it is a "dose estimate"

Media attention has heightened awareness

CT criticized for excessive radiation dose since 2001

Number 1:

Increase Awareness and Understanding of CT Radiation Dose Issues Among Radiologic Technologists

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 if possible
  - 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

Number 2:

Enlist the Services of a Qualified Medical Physicist

Number 2: Enlist Services of QMP

- Complex CT technical aspects required to generate quality images at reasonable doses
  - Opportunity to learn and experiment
  - Opportunity to keep up to date
  - Opportunity to teach technologists, radiologists in training
- Medical physicist should be American Board of Radiology or American Board of Medical Physics certified

Collaboration

Number 3:

Obtain Accreditation (e.g. from the American College of Radiology) for Your CT Program

Number 3: Obtain CT Accreditation (And, how about DICOE status too?)

- Deemed status organizations include IAC, The Joint Commission
- ACR requires quality image review
- Certification of radiologists, technologists, physicists, radiologists
- Radiologists must perform and document peer review
- ACR CT accreditation provides separate adult and pediatric accreditation:

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Number 4:

When Appropriate, Use an Alternative Imaging Strategy That Does Not Use Ionizing

Number 4: Use Alternative, Non-ionizing imaging exams

- CT saves lives, decreases need for exploratory surgery, decreases morbidity and mortality
- Sometimes, however, other strategies may work as well or better:
  - Test of time (observation)
  - Ultrasound
  - MRI

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Launched in Jan 2008 **The Simple Message:**

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)

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*Focused Assessment with Sonography in Trauma

Number 5:

Establish Baseline Radiation Dose for Your Patients

Number 5: Establish Baseline Dose for Your Patients

- Compare your doses to Diagnostic Reference Levels (DRLs)* from the ACR accreditation program and/or CT Dose Index Registry
  - Work with your medical physicist to estimate output doses for routine abdominal and head CT exams
  - Your measured patient doses should be less than the DRLs
  - SSDE adjusts the CTDIvol dose index for chest and abdomen

*Alternatives to the ACR DRLs exist, e.g., new pediatric European DRLs

Number 6:

Establish Radiation Doses for Pediatric Patients by "Child-Sizing" CT Scanning Parameters

Number 6: Establish Pediatric Doses—"Child-Size" It

- Start with doses from Number 5
- Adjust scanning field of view to smaller size of child
- Modify CT parameters to account for patient size—eg, start with Image Gently 'universal protocols' and reduce dose iteratively
  - See Number 7
  - Must balance image noise with image quality

Number 7:

Optimize (Pediatric) Examination Parameters—Part 1

Number 7: Optimize Exam Parameters

- **Center patient in CT gantry***
- *Perform Scout PA rather than AP* to decrease dose to lens, thyroid, breast, testes*
- Axial vs helical mode
  - Head CT
- Reduce detector size in z direction during acquisition

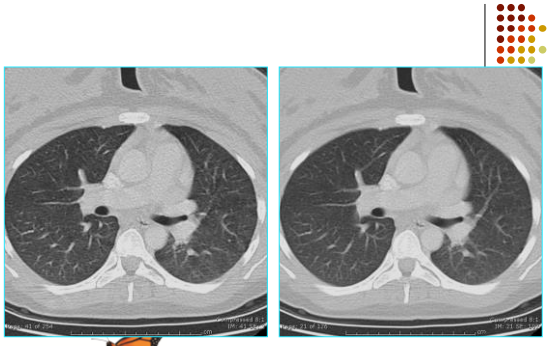
- Harri P, Moreno CC, et al. AJR 2014
- Filev P, Mittal P, et al. Curr Prob Diag 2016

Number 8:

Optimize (Pediatric) Examination Parameters—Part 2

Number 8: Optimize Exam Parameters

- Adjust the product of tube current and exposure time
  - mA X rotation time (typically 0.5 seconds)
  - Depends on patient size and clinical indication
- Adjust the kV (auto-kV, too)
  - Chest lower kV than abdomen
  - CT angiography allows lower kV
  - Neonates: 80
  - Infants: 80-100
  - Children: 100-120 (weight and indication based) kV



Normal exposure Over exposure

Number 8: Optimize Exam Parameters

- Increase pitch (not common);
- Scan only the indicated area
  - Often coverage extends further than needed 'to be safe'
  - Trauma 'pan-scan' of head, neck, chest, abd/pelvis
  - Pelvic CT vs limited to femoral head for closed reduction of developmental dysplasia of the hip
- Scan only one phase through the body part*
  - Limited justification for unenhanced followed by contrast-enhanced CT imaging or delayed imaging in children

*see Rostad B, Applegate K, et al. IPR 2016 abstract

Iterative Reconstruction

- Assumed a 'must have' and 'must do'
- Combinations of FBP and IR now exist—
  - Newer matrix models coming
- Body: more IR
- Neuro/Head: Less IR tolerated in general

Newer Protocols

- Newer equipment and protocols can achieve sub-mSv 'doses' with:
  - (Auto-mAs)—sometimes need boundaries for kids
  - Auto-kV—not intuitive for child vs adult settings
  - Dual energy CT
    - Sn150 filter 'iodine mapping' for lung or liver (dual 80/150) or 'virtual non-contrast' head (dual 100/150)
    - Pitch > 1.0 allows very fast acquisition and table speeds ('FLASH' < 1sec truncal CT)
  - Gated cardiac

Number 9:

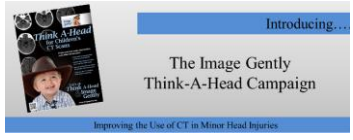
Participate in Lifelong Learning

Current state:

A. Head CT Justification- 3 Scenarios

- Child Abuse (yes!)
- ECMO baby in NICU (portable CT?)
- Minor Head Trauma (Think-A-Head Campaign: no?)

B. Optimization: CT Abdomen for Pain: >50% double scans from outside facility transfers Atlanta CHOA (IPR 2016 abstract)



Tecky Cool Stuff--How far have we come: 2007 to 2017

- Case 1: 2 yr old girl with hepatoblastoma f/u has chest CT; CTDIvol <0.1mGy
- Case 2: 7 year old boy Cx pancreatitis, new titanium stent, with ?SMV clots; Dual energy abdomen pelvis CT dx SMV narrowing adjacent to stent (no artifact). CTDIvol =1.0 mGy

Number 9: Participate in Lifelong Learning

- Considerations include:
  - American Board of Radiology-- Maintenance of Certification/Continuous Credentialing (every 10 yrs)
  - Quality Assurance and Improvement Projects
  - Multidisciplinary Conferences
  - Journal Clubs

Number 10:

Obtain Decision Support Software for Your Health System's Computerized Physician Order Entry (CPOE)

Number 10: Obtain Decision Support for Your Health System's CPOE

- This tool allows:
  - Use of the radiation protection principle of justification---where the patient benefit should outweigh the risk of the imaging test ordered
  - Evidence-based data at the point of care
  - MPFS CY2018 rule compliance (1/1/2019)
- Example: use electronic ACR or UK/ESR Appropriateness Criteria
  - Includes relative radiation dose categories

Summary

- Preparation of patients and family is critical to success of pediatric CT
- Pediatric protocols (and pathology) differ from adult protocols in many ways
  - Pediatric radiologists--for general body CT imaging, are comfortable with noisy images—trading image quality for lower dose
- CT Report: SSDE for body and soon for Head (AAPM TG 293)
- New complexity has brought tremendous results: dual energy CT, auto-kV, and new IR methods, bring sub-mGy dose estimates (CTDIv) to REALITY!
- Commit to lifelong learning across disciplines--Dose Manage via Audits or Registry participation

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On behalf of all the children and their families that I see:
Thank You for all you do to help us make them better!
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"Nothing is to fear, only to understand."
Marie Curie

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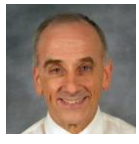


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