Overview
- Paediatric radiation safety
- General guidelines
- Protocols

Paediatric Radiation Safety
- Paediatric patients are unique
- Children are more susceptible to radiation induced cancer than adults
- Younger children are more sensitive
- Girls more than boys (breast / thyroid)

Imaging Indications
- Radiation - ALARA
- General Radiation Risk
- Lowest dose per investigation
- Sens & Spes
- Cost Effective
Radiation effects

- Formation of free radicals
- Body repairs damage
- Permanent DNA alteration (stochastic effect)
- Cell death (deterministic effect)
- No permanent damage

Deterministic = dose dependent with threshold
- Hairloss, Burns, infertility, cataracts, etc.

Stochastic = potential for cancer / genetic effects
- Dose = 1 risk. No threshold
- Cancer

Hair loss, Burns, Infertility, Cataracts, etc.
Stochastic = potential for cancer / genetic effects.
↑ Dose = ↑ Risk. No threshold
Cancer

Relative radiation dose

<table>
<thead>
<tr>
<th>Source</th>
<th>Estimated Dose</th>
<th>Equivalent to background</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical background</td>
<td>Background</td>
<td>None</td>
</tr>
<tr>
<td>CT (standard)</td>
<td>2.0 mSv/scan</td>
<td>20,000</td>
</tr>
<tr>
<td>CT (low dose)</td>
<td>0.20 mSv/scan</td>
<td>2,000</td>
</tr>
<tr>
<td>CT (sub-setting)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interventional</td>
<td></td>
<td></td>
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<tr>
<td>Fluoroscopy</td>
<td></td>
<td></td>
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<tr>
<td>Nuclear medicine</td>
<td></td>
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<tr>
<td>Radiographs</td>
<td></td>
<td></td>
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<tr>
<td>Ultrasound/MR</td>
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</tr>
</tbody>
</table>

Modality
- CT
- Interventional
- Fluoroscopy
- Nuclear medicine
- Radiographs
- Ultrasound/MR

- None

Background equivalent
- 8 months +
- 1 - 6 months +
- 10 days +
- 1 day +
- 1 day -

Radiation Dose Chart

- CT
- Interventional
- Fluoroscopy
- Nuclear medicine
- Radiographs
- Ultrasound/MR

Relative radiation dose

- 0.20 mSv/scan
- 2.0 mSv/scan
- 20,000
Relative Risk

<table>
<thead>
<tr>
<th>Activity</th>
<th>Death (per million/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Being a person age 55 years (all causes)</td>
<td>10,000</td>
</tr>
<tr>
<td>Smoking a pack of cigarettes daily (all causes)</td>
<td>3,500</td>
</tr>
<tr>
<td>Rock climbing for 2 months (cancer from cosmic rays)</td>
<td>1</td>
</tr>
<tr>
<td>Living in the vicinity of a nuclear power plant (radiation-induced cancer)</td>
<td>&lt;0.1</td>
</tr>
</tbody>
</table>

AAPM Mission Statement

- Discussion of risks related to radiation dose from medical imaging procedures should be accompanied by acknowledgement of the benefits of the procedures.
- Risks of medical imaging at effective doses below 50 mSv for single procedures or 100 mSv for multiple procedures over short time periods are too low to be detectable and may be nonexistent.

How do we reduce radiation?

- Image appropriately!
  - Best investigation for question
- “Child-size” the amount of radiation used
  - Technical stuff your Radiologist need to know about
- If we CT-Scan
  - Only when necessary
  - Only indicated region
  - Only once

Who is responsible for reducing radiation?

- Radiologist
  - Offer appropriate service
  - Reduce radiation (technical)
  - Offer affordable service

- Referring clinician
  - Understand modern imaging
  - Imaging “educated”
  - Cautious of radiation exposure
Working together

- Image Gently
  - The Alliance goal is to change practice: to raise awareness of the opportunities to lower radiation dose in the imaging of children
- SASPI
  - South African Society of Paediatric Imaging
- ACR
  - American College of Radiology
  - ACR Appropriateness Criteria

Practical Points

- Extremities
- Comparative views
- Head and Neck
- Skull X-rays
- Convulsions
- Sinus X-rays
- Chest
- Lateral chest X-rays
- Abdomen
- Reflux / GORD
- HPS
- Intussusception
- Appendicities
- Pelvis
- OSH
- Urinary System
- Urinary tract infection

Comparative views

- Generally not indicated
- Only on request for subtle or confusing appearances
- Exceptions
  - Skeletal survey
  - Measurements for Orthopods
Practical Points

- Extremities
  - Comparative views
- Head and Neck
  - Skull X-rays
  - Contrasat
  - Sinus X-rays
- Chest
  - Lateral chest X-rays
- Abdomen
  - Reflux / GORD
  - HPS
  - Intussusception
  - Appendicitis
- Pelvis
  - DDH
- Urinary System
  - Urinary tract infection

Head injury / Skull X-rays

- Not indicated at institutions with CT facilities.
  - If no CT available, may be used in mild head injury ➔ visualised fracture ➔ indication for CT
- May be done as part of skeletal survey in suspected NAI (Leave if doing CT) & surgical follow-up for device implantation
- CT preferred for head shape abnormalities / craniosynostosis.

SASPI

ii. Imaging protocol for head injuries

- No role for skull x-rays
- Currently no role for cranial ultrasound
- CT head – low threshold for imaging except in resource-limited setting, then employ the following guidelines for CT referral:
  - GCS ≤ 14 on assessment at hospital after adequate resuscitation
  - Abnormal drowsiness
  - Focal signs
  - Penetrating injury
  - Suspected base of skull fracture
  - Clinical suspicion of occipital / suboccipital fracture
  - NAI
  - Post-traumatic seizure
  - Vomiting > 3 times or > 2 hours post injury
ACR Head injury

- Minor injury - GCS>13, Θ Risk Fx
  - No imaging
- Moderate / Severe – GCS <13, ± Risk Fx
  - CT brain pre-contrast (? MRI pre)
- NAI
  - CT brain pre-contrast / MRI Brain DAI
- Subacute HI with Neuro Sx
  - MRI brain pre / CT brain pre

Cochlear implant – Surgical Cx

Sinus / Adenoids X-rays

- Very limited value!
- Sinus complaints should receive empirical treatment without imaging except
  - Features of complication
  - Surgical planning
  - CT is then indicated

Craniosynostosis
Adenoid hypertrophy

Sinuses

SASPI – CT Sinuses

Indication

| (A) | Only after trial of therapy if planning endoscopic surgery |
| (B) | Complicated Sinusitis – Orbital cellulitis/intracranial extension? |
| (D) | Do not image children under 2 years, particularly not under 2 years |
| (E) | After trial of therapy prior to surgery |
| (B) | Complicated Sinusitis – Orbital cellulitis/intracranial extension? |

Contrast:
- Non-C
- Post-C: ONLY
- 2 mL/kg
- No Delay
ACR Sinusitis

- Uncomplicated acute sinusitis
  - NO IMAGING
- Persistent, recurrent or chronic sinusitis
  - CT Sinuses pre-contrast
- Complicated sinusitis (Orbital / Intracranial)
  - CT brain and sinuses with contrast (? MRI with contrast)

Convulsions

- Modality differs between ages
- Correlating clinical history of vital importance.

ACR - Convulsions

Practical Points

- Extremities
  - Comparative views
- Head and Neck
  - Skull X-rays
  - Convolutions
  - Sinus X-rays
- Chest
  - Lateral chest X-rays
- Abdomen
  - Reflux / GORD
  - HPS
  - Intussusception
  - Appendicities
- Palms
  - ODH
- Urinary System
  - Urinary tract infection
Lateral Chest X-ray

- Not routinely used in USA / UK
- Valuable in SA for detecting TB lymph adenopathy
  - CT more accurate, but not feasible to perform in every case of suspected TB

Practical Points

- Extremities
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- Skull X-rays
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- Sinus X-rays
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  - HPS
  - Intussusception
  - Appendicitis
- Pelvis
  - DDH
- Urinary System
  - Urinary tract infection

Bowel imaging

- X-ray evaluation very limited
- Only absolute x-ray indication
  - Obstruction / Perforation
  - Positioning of lines
- Non-specific abdo pain
  - Constipation
  - Very limited value!

**Bowel imaging**

- **Reflux / GORD**
  - Barium swallow limited value early
  - Physiological reflux / ? When abnormal

- **Hypertrophic pylorus stenosis**
  - Ultrasound first line
  - Barium studies only in difficult / equivocal cases

**Hypertrophic Pyloric Stenosis**

- Ultrasound first line
- Barium studies only in difficult / equivocal cases

**Intussusception**

- Ultrasound first line
- Barium studies only in difficult / equivocal cases
Bowel Imaging - Appendicitis

- **X-ray**
  - Rarely helpful – may show focal ileus which is non-specific

- **Ultrasound** is still first line investigation
  - Can be difficult due to location, bowel gas, etc.
    - Abnormal ultrasound = Appendicitis
    - Normal ultrasound ≠ Normal ≠ Appendicitis
    - Can demonstrate mesenterial glands / Adenitis

- **CT** as next line investigation
  - Single venous phase + oral/rectal contrast

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**Appendicitis - US**

**Appendicitis**
Appendicitis

Intussusception

Appendicitis – ?Pre / ? Post

Practical Points

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- Pelvis
  - DDH
- Urinary System
  - Urinary tract infection
Pelvic X-rays

- Limited value for DDH
  - Ultrasound preferred
- Bony lesions, Perthe’s and SUFE possible with X-rays, but
  ➔ MRI more sensitive

DDH

Practical Points

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Summary

- Radiation Dose & Risk
- Radiation reduction
- Appropriate imaging for the clinical question

Questions / Comments