Eye Doses in Head CT; Sequential Vs Spiral
CT Users Group October 2010

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Synopses

- CT head scanning at Portsmouth
- Why look at eye doses in head CT?
- Why choose Spiral over Sequential?
- ImPACT assessment of eye doses
- TLD assessment of eye doses
- Topogram Eye doses
- Review of patient images (scan positions)
- Individual patients receiving multiple head scans
Routine Head Scans

- Clinical Preference is to change from routine head sequential scans to Routine Spiral scan
- Lead radiographer in CT has produced scan protocol for spiral scans, but sought Medical Physics advice on eye doses before change was fully implemented
  - PHT historically had two 4 slice VZ scanners – almost all head scans were sequential
  - PFI has introduced additional scanners to QAH site (one 40 slice, one 128 slice in addition to one of the old 4 slice scanners) this has come with a move towards increasing spiral scanning
  - Old 4 slice rarely used for Routine heads (occasional use if volume needs arise), these are done routinely on the 40 and 128 slice
Siemens Sensation 40

Siemens Definition AS+ 128
Why look at eye doses in head CT…….
Importance of Eye doses

- Lens of the eye is known to be radiosensitive (ICRP 103 data)
  - Detectable opacities form with chronic exposure >5Gy, or >100mGy/yr
  - Acute exposure >500mGy
- NICE guidelines suggest that CT should be used instead of skull x-ray for head injuries
- Increase in use of CT scanners for head exams – 50% increase in last 5 years
- Recent papers suggest that lens damage could be without a threshold and so doses should therefore be ALARP
Why choose Spiral over Sequential…….
Sequential Vs Spiral scanning

- **Why scan sequentially?**
  - Potential for significantly lower eye doses……The scanner can be tilted to avoid the eye. Together with tilting the patients head should allow the eye to be excluded from the scan in the majority of cases (with good radiographic practice)
  - Useful for stroke patients

- **Why scan spiral?**
  - Spiral scans can be reconstructed in any orientation giving valuable clinical information not available with sequential scans
  - Greater flexibility with straightening up scans if patient is not properly aligned
  - Useful for dementia diagnosis (reconstruct along the line of the silvian fissure – shows temporal lobe abnormality)
The ideal scan position........
Correct positioning for a routine CT head
Assessment of Eye doses.........
## Calculated doses - ImPACT

### ImPACT CT Patient Dosimetry Calculator

**Scanner Model:**
- Manufacturer: Siemens
- Scanner: Somatom Perfomax 256 Slice

**Acquisition Parameters:**
- Tube current: 174 mA
- Rotation time: 0.75 s
- mAs / Rotation: 130.5 mAs
- Collimation: 1 (2mm)
- Slice Width: 4 mm
- Pitch: 0.87

**Scan Range:**
- Start Position: 91 cm
- End Position: 91 cm
- Patient Size: m

<table>
<thead>
<tr>
<th>Organ</th>
<th>Vt</th>
<th>Ht</th>
<th>Ht+Hv</th>
<th>Ht</th>
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<tbody>
<tr>
<td>Glands</td>
<td>0.2</td>
<td>0.6</td>
<td>0</td>
<td>0.4</td>
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<tr>
<td>Bone Marrow (ed)</td>
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<td>1.2</td>
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<td>Colon</td>
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<td>1.3E-05</td>
<td>0.00815</td>
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<td>0.0035</td>
<td>0.154</td>
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<td>0.013</td>
<td>0.0016</td>
<td>0.0145</td>
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<tr>
<td>Bladder</td>
<td>0.05</td>
<td>0</td>
<td>0</td>
<td>0.05</td>
</tr>
<tr>
<td>Breast</td>
<td>0.05</td>
<td>0.011</td>
<td>0.0055</td>
<td>0.0056</td>
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<tr>
<td>Liver</td>
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<td>0.0022</td>
<td>0.00011</td>
<td>0.00022</td>
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<tr>
<td>Oesophagus (Thymus)</td>
<td>0.05</td>
<td>0.024</td>
<td>0.0002</td>
<td>0.0003</td>
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<tr>
<td>Thyroid</td>
<td>0.05</td>
<td>0.44</td>
<td>0.022</td>
<td>0.0022</td>
</tr>
<tr>
<td>Skin</td>
<td>0.01</td>
<td>11</td>
<td>3.01</td>
<td>0.31</td>
</tr>
<tr>
<td>Bone Surface</td>
<td>0.01</td>
<td>4.9</td>
<td>0.049</td>
<td>0.049</td>
</tr>
<tr>
<td>Brain</td>
<td>0.028</td>
<td>25</td>
<td>0.03</td>
<td>0.03</td>
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<tr>
<td>Remainder 2</td>
<td>0.42</td>
<td>0.24</td>
<td>0.061</td>
<td>0.061</td>
</tr>
</tbody>
</table>

**Total Effective Dose (mSv):** 0.96

**Herniated Organs:**
- Adrenals: 0.0031
- Brain: 25
- Upper Large Intestine: 0.00021
- Small Intestine: 0.00018
- Kidney: 0.00032
- Pancreas: 0.0016
- Spleen: 0.0021
- Thymus: 0.024
- Uterus: 0.0002
- Muscle: 0.26

**DRL (mSv/cm²):** 175

**CTDI (mGy):** 217

**CTDI (mGy):** 24.9

**DLP (mSv/cm²):** 175
Scan parameters:

<table>
<thead>
<tr>
<th></th>
<th>Sensation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spiral</td>
<td>Sequential</td>
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<tr>
<td>Effective mAs</td>
<td>360</td>
<td>380</td>
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<tr>
<td>kV</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>Slice thickness, mm</td>
<td>4.0mm</td>
<td>3.0 mm</td>
</tr>
<tr>
<td>Collimation</td>
<td>24 x 1.2mm</td>
<td>20 x 0.6 mm</td>
</tr>
<tr>
<td>Pitch</td>
<td>0.8</td>
<td>1</td>
</tr>
<tr>
<td>Rotation time, sec</td>
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<td>1</td>
</tr>
<tr>
<td>CTDI (air), mGy/100mAs</td>
<td>17.8</td>
<td>17.8</td>
</tr>
<tr>
<td></td>
<td>Spiral</td>
<td>Sequential</td>
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<tr>
<td>Effective mAs</td>
<td>350</td>
<td>420</td>
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<tr>
<td>kV</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>Slice thickness, mm</td>
<td>4.0mm</td>
<td>4.8 mm</td>
</tr>
<tr>
<td>Collimation</td>
<td>40 x 0.6mm</td>
<td>32 x 1.2 mm</td>
</tr>
<tr>
<td>Pitch</td>
<td>0.65</td>
<td>1</td>
</tr>
<tr>
<td>Rotation time, sec</td>
<td>0.5</td>
<td>2</td>
</tr>
<tr>
<td>CTDI (air), mGy/100mAs</td>
<td>22</td>
<td>22</td>
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</table>
Practical measurements

- Rando phantom used as patient to give realistic set-up
- Radiographers assisted with setting rando up on the scanner, and defining fields of view that they would aim to achieve
- TLDs used to establish eye doses
9cm row of TLDs
Definition AS+ Spiral scan including the eye
Definition AS+ Spiral scan excluding the eyes
Comparison of Spiral Vs Sequential calculated eye doses
Comparison of Spiral Vs Sequential measured eye doses

![Bar chart showing comparison of spiral vs sequential measured eye doses for different scanners and eye positions. The chart includes data for S40 (no eyes) and S40 (with eyes) scanners, and D128 (no eyes) and D128 (with eyes). The y-axis represents dose in mGy, and the x-axis represents scanners and eye positions. The bar colors indicate spiral (blue) and sequential (red) methods.]
Topogram doses....

Should a topogram be repeated if the patient moves?

<table>
<thead>
<tr>
<th></th>
<th>R eye</th>
<th>L eye</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition</td>
<td>0.13 mGy</td>
<td>0.25 mGy</td>
</tr>
<tr>
<td>Sensation</td>
<td>0.44 mGy</td>
<td>0.17 mGy</td>
</tr>
</tbody>
</table>

128 slice scanner
40 slice scanner

Yes !!
Patient positioning audit

- Local protocol is that the patient should be positioned such that the eye is avoided from the scan plane
However, a significant number of patients have eyes included in the scan plane.

Reasons:
- Cannot tilt patients head
- Cannot tilt scanner in spiral scanning
- Miscellaneous
Percentage of patients that are scanned with eyes included in the scan plane

Proportion of eye in the scan plane

- Spiral scan
- Sequential scan
Patients with multiple scans

- Using the Radiology Information System (RIS) system, the rates at which head scans are repeated were analysed

**Number of exams for a 25 month period**

| Total Routine head sequential scans undertaken | 6849 |

**Repeat Rates - total for a 25 month period**

*Sample of ~7000 patients*

| Total patients with 1 scan | 90.2 % |
| Total patients with 2 scans | 8.3 % |
| Total patients with 3 scans | 1.1 % |
| Total patients with 4 scans | 0.2 % |
| Total patients with 5 scans | 0.1 % |
| Total patients with 6 scans | 0.1 % |
Conclusions

- With ideal practice eyes are more likely to be excluded from the scan plane with sequential scanning.
- When eyes are included in the scan plane (either compromised [time issues or insufficient training] practice or lack of patient mobility), sequential scanning results in doses 7–22% higher than spiral scanning.
- Practice could potentially be improved if an additional topogram is taken prior to the scan, if this is more likely to allow the eyes to be excluded.
- Sequential scanning should be used where there is adequate patient mobility to fully exclude the eyes, and sufficient clinical information will be gained.
- Spiral scanning should be used for patients with poor mobility that would mean that eyes cannot be excluded or if reconstructing in additional planes will be useful.
- Patients receiving 3 or more scans per year could be accumulating doses of concern (ICRP). All patients with eyes included in the scan field unnecessarily could be of concern if there is no (or a lower) threshold.
Any Questions?