Computed Tomography Scanning

Jared Leichner
Advantages

- Elimination of Superposition
- Soft Tissue Differentiation
- Multiplanar Reformatted Imaging
- Reduction of Need for Exploratory Surgery

Elimination of Superposition

* Note the fine details that become apparent

Unnecessary Surgery

http://www.annals.org/content/152/8/505.full
Disadvantages

- Radiation Dosage
- Potential For Unnecessary Use
- Allergic Reactions to Contrast Agents
- Misconceptions of Radiologists

# Large Radiation Dose

## Typical Organ Radiation Doses From Various Radiologic Studies

<table>
<thead>
<tr>
<th>Study Type</th>
<th>Relevant Organ</th>
<th>Relevant Organ Dose (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dental Radiography</td>
<td>Brain</td>
<td>0.005</td>
</tr>
<tr>
<td>P/A Chest Radiography</td>
<td>Lung</td>
<td>0.01</td>
</tr>
<tr>
<td>Lateral Chest Radiography</td>
<td>Lung</td>
<td>0.15</td>
</tr>
<tr>
<td>Screening Mammography</td>
<td>Breast</td>
<td>3</td>
</tr>
<tr>
<td>Adult Abdominal CT</td>
<td>Stomach</td>
<td>10</td>
</tr>
<tr>
<td>Neonatal Abdominal CT</td>
<td>Stomach</td>
<td>20</td>
</tr>
</tbody>
</table>

Large Radiation Dose

Abdominal CT, 240 mAs

Estimated Lifetime Attributable Risk of Death from Cancer (%)

Age at Time of CT Study (yr)

Allergic Reactions

- Reaction: 4-8%
- Anaphylaxis: 1%
- Death: 0.001-0.009%

http://allergycases.org/2008/08/allergic-reaction-to-intravenous.html
Internal Misconceptions

• Survey of Radiologists & ER Physicians
  – 75% Significantly Underestimated Radiation Dose

• Do CT Scans Increase the Lifetime Risk of Cancer?
  – 53% of Radiologists said No.
  – 91% of ER Physicians said No.

Common Medical Applications

• Screening of Lungs of a Smoker

Common Medical Applications

• Virtual Colonoscopy

Common Medical Applications

• Virtual Colonoscopy

http://www.scandirectory.com/blog/default.asp?q=virtual+colonoscopy
Common Medical Applications

- Cardiac Screening

http://pmj.bmj.com/content/86/1017/445.extract
Common Medical Applications

- Appendicitis Diagnosis

http://radiographics.rsna.org/cgi/content-nw/full/28/2/393/F10A
Non-Medical Applications

Thermodynamics of porous mixtures

Evaluation of Timber Quality

Analyzing Soil Fertility

http://findarticles.com/p/articles/mi_hb3387/is_1_74/ai_n28947474/
Mixture Thermodynamics

Mixture Thermodynamics

Timber Quality Control

Soil Fertility

Progression of the Technology
A Brief Comparison

1975 Scan

2006 Scan

http://web2.uwindsor.ca/courses/physics/high_schools/2006/Medical_Imaging/cthistory.html
1972 - Inception

- Invention by Godfried N. Hounsfield
- Non-Superimposed Images of a Cross-Section
- Several Hours / Slice
- Several Days / Reconstructed Image

1st Generation

Highly Collimated Pencil Beam
Excellent Scatter Rejection
Long Scan Times (5 min)

http://www.youtube.com/watch?v=fNaCxhhhZTE
2nd Generation

Shorter Scan Time
(Faster Angular Component)

Complicated Reconstruction

http://www.youtube.com/watch?v=Ni4Hsi3GhXo
3rd Generation

Full Rotation
No Translation
1 Second Scan

http://www.youtube.com/watch?v=bdf0kXn5Eeg
4th Generation

600-4800 Fixed Detectors

Rotating Fan Beam

http://www.youtube.com/watch?v=AWVz3yke_bY
5th Generation

- No Moving Parts
- Subsecond Scan Time
- Stationary Detector Array

http://www.youtube.com/watch?v=ww2TZWagDc&feature=related
1974 - Commercialization

- Dedicated to Head Imaging
- Only Two Sold

1976 – Full Body Scans

- Introduction of a Gantry
- 5s Scan Time/Slice

1978-1983

Somatom II - 1978
- ECG Synchronized CT Image

Somatom DR III - 1983
- 3s Scan Time/Slice
- 1 mm Slice Width

Somatom DRH - 1985
- 25 Degree Gantry Tilt Angle
- Integrated Multi Planar Reformatting

1988-1994

Somatom Plus - 1988
• Continuous Rotation of Tube and Detector
• 1s Scan Time/Slice

Somatom AR - 1991
• Windows User Interface
• Spiral CT Scanner

Somatom Plus 4 - 1994
• 0.5s Scan Time / Slice

1998-2002

Somatom Volume Zoom - 1998

- 125ms Temporal Resolution during Cardiac Surgery
- ‘Sureview’ Reconstruction Algorithm

Somatom Sensation - 2002

- Multislice Scanning – 16 per Rotation
- 105ms Temporal Resolution during Cardiac Surgery

State of the Art CT

Scanner
- X Ray Tube – Various Focal Spot Sizes
- Shielding – Grids, Collimators, Filters

Detector
- Single Row Detectors
- Multi Row Detectors

Image Reconstruction
- Volume Rendering

Most Recent Challenge

Reducing Unnecessary Radiation From Spiral Scans

Red Zone – Unnecessary Radiation

Solution: ‘Breathing’ Tube Side Collimator
Typical Device Cost

- 1992 Somatom AR.T (4.5k)
- 2000 Somatom+ 4 (45k)
- 2002 Somatom Sensation 16 (850k)
- 2005 Somatom Sensation 64 (650k)
- 2008 Somatom Definition (380k – 580k)
- 2011 Somatom AS+ (3 Million)
  - Two x-ray sources

Typical Scan Cost

- ($600-$3000)
- ($300-$1500)
- $3000
- 40% Discount for Uninsured Patients & Payment Plan

http://www.comparecatscancost.com/
http://blog.remakehealth.com/blog_Healthcare_Consumers-0/bid/7499/How-much-does-a-CT-Scan-cost
http://answers.yahoo.com/question/index?qid=20061006104857AAxgwOx
http://answers.yahoo.com/question/index?qid=20080224095624AA1PFHh
Annual Use in the USA