CT in Obesity: Tips and Tricks

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**Obesity Trends Among U.S. Adults**


(*BMI ≥30, or about 30 lbs. overweight for 5'4" person*)

**Modica M J et al.**

Radiographics 2011;31:811-823

**Frequency of Obesity**

- 2-5 years
- 6-11 years
- 12-19 years

**Charts and Graphs:**

- Prevalence (%) over different age groups and time periods.

## Obesity: Consequences

**Table 1** Consequences of obesity in the radiology

<table>
<thead>
<tr>
<th>Consequences:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missed Diagnoses</td>
</tr>
<tr>
<td>Non-diagnostic scans</td>
</tr>
<tr>
<td>Equipment failure/breakage</td>
</tr>
<tr>
<td>Embarrassing situation for patients</td>
</tr>
<tr>
<td>Increased radiation dose to patients and staff</td>
</tr>
</tbody>
</table>

Buckley et al. European Radiology 2009
Issues with Obesity

1. Fit?
   - Weight: Table limits
   - Circumference: Gantry limits

2. Image Quality?
   - kV /mA /rotation time /pitch
   - Field of View
   - Kernels
   - Slice thickness
Are they too big for the gantry? Check Width
Will the table move? Check Weight

<table>
<thead>
<tr>
<th>Scanner Manufacturer and Model</th>
<th>Aperture Diameter (cm)</th>
<th>Maximum Reconstruction FOV (cm)</th>
<th>Maximum Table Load (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE Healthcare</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LightSpeed VCT</td>
<td>70</td>
<td>50</td>
<td>500</td>
</tr>
<tr>
<td>LightSpeed Xtra</td>
<td>80</td>
<td>65</td>
<td>650</td>
</tr>
<tr>
<td>Philips</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brilliance CT 64-Channel</td>
<td>70</td>
<td>50</td>
<td>450*</td>
</tr>
<tr>
<td>Brilliance CT Big Bore</td>
<td>82</td>
<td>70</td>
<td>650</td>
</tr>
<tr>
<td>Siemens</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Somatom Definition AS</td>
<td>78</td>
<td>78</td>
<td>485†</td>
</tr>
<tr>
<td>Somatom Sensation Open</td>
<td>82</td>
<td>82</td>
<td>615</td>
</tr>
<tr>
<td>Toshiba</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquilion 64</td>
<td>72</td>
<td>50</td>
<td>450†</td>
</tr>
<tr>
<td>Aquilion Large Bore</td>
<td>90</td>
<td>70</td>
<td>450</td>
</tr>
</tbody>
</table>

Girth and weight

- Always subtract table (15-18cm) from gantry aperture!!
  - 90 cm gantry aperture can only allow patients up to 72-75 cm girth
- Check weight limits with the service people
- Check with your Radiation therapy folks!
- Call around town if yours won’t fit! GOOGLE “Bariatric CT”
Concerns on Imaging

- Noise
  - Higher irrespective of kVp and mAs
- Artifacts
  - Beam hardening
  - Truncation
CT- Noise & Artifacts

Noise - fixed mAs

Increase mAs

"Automatic"
Decrease gantry rotation speed
Decrease pitch
Dual source CT?
Photon starvation artifact
CT Limitation – Beware of Cropping

Gantry fit does not guarantee FOV with skin to skin coverage: Ex: Melanoma
CT- Is Fat Good?

180 lbs

Paucity of Fat

300 lbs

Intraperitoneal Fat
CT- Patterns of Fat Distribution

300 lbs

Extraperitoneal: Not so good

Intraperitoneal: Good
Head CT in obesity

• Just check the weight limit of the scanner.
• Patient girth is not important to check
• Image quality is not much affected since head size does not change much.

• **Generally, no protocol change needed**
Chest CT in morbidly obese

Step 1: Check weight and girth limits of the CT.

Step 2: Chest CT in Morbid obesity (ex. > 300 lbs):

• Lung nodule FU, cancer screening protocols: Generally ok
  • Slight increase in mAs to 80 @ 120 kV
• CT pulmonary embolism:
  • Increase contrast injection rate and volume (>5-6 ml/second)
  • 120 kV sufficient: Avoid 140 kV
  • Apply iterative reconstruction technique (IRT)
Abdominal CT in morbid obesity

- CT Abdomen is most affected in severe obesity
- Best case scenario: High end CT
  - High x-ray tube power $\geq 120$ kV and $\sim 800$ mA
  - Large gantry aperture
  - Higher weight limits
  - Iterative Reconstruction
Abdominal CT in morbid obesity

- Milking photons from CT scanners
  - 1\textsuperscript{st}: Increase mA
  - 2\textsuperscript{nd}*: Slow down gantry rotation speed
  - 3\textsuperscript{rd}: If needed decrease the pitch
- BMI $\geq$40: 140 kV (routine); 120 KV (CTA)

| Table 1
<table>
<thead>
<tr>
<th>Multi-slice CT Scanning Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td>------------------------------------</td>
</tr>
<tr>
<td>Detector configuration</td>
</tr>
<tr>
<td>Peak kilovoltage (kV)</td>
</tr>
<tr>
<td>Tube current (mA)</td>
</tr>
<tr>
<td>Gantry rotation time (seconds)</td>
</tr>
<tr>
<td>Tube current-time product (mAs)</td>
</tr>
<tr>
<td>Beam pitch</td>
</tr>
<tr>
<td>Table feed per gantry rotation</td>
</tr>
<tr>
<td>(mm)</td>
</tr>
<tr>
<td>Table speed (mm/second)</td>
</tr>
<tr>
<td>Reconstructed slice thickness</td>
</tr>
<tr>
<td>(mm)</td>
</tr>
<tr>
<td>Estimated dose length product</td>
</tr>
<tr>
<td>(mGy/cm\textsuperscript{+})</td>
</tr>
<tr>
<td>Acquisition time (seconds)</td>
</tr>
</tbody>
</table>

*Maximum allowed by the manufacturer.
+Estimated for a scan coverage of 500 mm.
Abdominal CT in obesity

• Increase image thickness:
  • Doubling leads to 41% increase in SNR
  • Decreases image noise
  • Increases partial volume averaging- overlap and off-axial MPR
• Softer reconstruction kernel
• Iterative reconstruction techniques (FIGURE)
• Image filters
• Wider window level and width
Lung findings and Obesity

Post mortem CT
120 kV with mAs changes
310 lbs : BMI 37
3 mm images
No effect on lesion visibility
Liver and Obesity

Post mortem CT
120 kV with mAs changes
310 lbs: BMI 37
5mm Abdomen WW/WL 400/50

Noise: lower
Soft tissues: better
250 lbs 14 mGy
250 lbs 1.6 mGy
250 lbs 1.6 mGy
Cardiac CT in Severe Obesity

- Higher dose needed compared to average patients
  - 120 / 140 kV based on patient size (80-100 kV for others)
  - Higher mAs (apply AEC)
  - Avoid high pitch scanning mode
- Iterative reconstructions
- Higher contrast volume as well: 6-7 cc per second
Effect of Obesity on Estimation of Organ Doses

Courtesy: George Xu, PhD
NIH/NIBIB: RO1 “GPU-Based Monte Carlo Software for Computing CT Imaging Doses”
CONCLUSIONS

Obesity impacts CT and dose.

1. There are equipment weight and girth limits.

2. Technique modification can help

3. Reconstructed FOV (50 cm) may not have skin to skin coverage.