Hepatic Dual Energy CT

William P. Shuman, MD, FACR, FSCBTMR
University of Washington
Department of Radiology
Seattle, WA
Our Dual Energy CT Experience: GE HD750 Rapid-Switch
Physical Basis
Dual Energy CT: Potential Liver Applications

- Enhance the subtle lesion
- Tumor versus cyst
- Focal fat, iron, fibrosis
- Response to Y-90 and ablation
- Virtual unenhanced
- Artifact reduction
- Workflow
Enhancing the Subtle Lesion
Enhancing Subtle Lesions

- Markedly increased HU Density of Iodine at energy levels just above the outer shell electron binding energy (33 keV)
  - Iodine K-edge

- DECT polychromatic raw data obtained from 80 and 140 kVp scanning can be postprocessed to create synthetic monochromatic images at single keV levels between 40 and 140 keV
Enhancing Subtle Lesions

• In patients with cirrhosis, CT imaging is frequently used to screen for early detection of hepatocellular carcinoma (HCC).

• HCC often presents as a focal hyperenhancing liver lesion in arterial phase with delayed washout.

• Dual Energy CT may make the arterial phase iodine blush of HCC appear brighter.
Enhancing Subtle Lesions

• Low keV images make iodine very bright but also have increased image noise compared to higher keV images.

• DECT can also be postprocessed to map the concentration of iodine in tissue as a basis pair with water (material decomposition).

• Together, these effects may improve hypervascular lesion conspicuity during iodine enhanced DECT of the liver.
Dual Energy Monochromatic Imaging: HCC

40 kev

80 kev
Dual Energy: The Big Questions

Might dual energy CT in patients with end stage liver disease improve hypervascular lesion (HCC) -

- **Conspicuity** of individual lesions
- **Number** of lesions detected
- **Accuracy** of measurements
- **Characterization** of lesions
The Very Subtle Early Blush

50 keV

Iodine Only
Tumor versus Cyst
Hypodense Liver Lesions: Met vs. Cyst

GSI Projection Based Dual Energy

Published in: “Automated liver lesion characterization using fast kVp switching dual energy computed tomography imaging”
Santamaria-Pang et al.
Proc. SPIE 7624, Medical Imaging 2010
Evaluate the ability of liver DECT monochromatic and material decomposition data from only the arterial phase to differentiate perfused solid lesions from cysts
Dual Energy Monochromatic Imaging: HCC

70 keV
On Postprocessing Workstation: From arterial phase DECT data only, plotted keV vs HU from lesion and liver:

- **Iodine Present**: curve shape similar to liver, greater than 20 HU change between 40 - 60 keV
- **Iodine Absent**: flat curve compared to liver, less than 20 HU change between 40 - 60 keV
Liver Lesion

Iodine Present
Greater than 20 HU change in the 40-60 keV range, shape similar to liver
Adding an Iodine threshold to an iodine image

Without threshold

With 2 mg/ml threshold
Lesion
Liver

Iodine absent
Less than 20 HU change in the 40-60 keV range, flat shape
Iodine material density image shows iodine within the lesion (arrow), indicative of an enhancing solid mass.
Bland vs. Tumor Thrombosis in PV

Published in: "Dual-energy CT with iodine quantification in distinguishing between bland and neoplastic portal vein thrombosis in patients with hepatocellular carcinoma" Ascenti et al. Clinical Radiology, 2016, Available online 27 May 2016
Published in: "Dual-energy CT with iodine quantification in distinguishing between bland and neoplastic portal vein thrombosis in patients with hepatocellular carcinoma"
Ascenti et al.
Clinical Radiology, 2016, Available online 27 May 2016
Liver Fat, Iron, Fibrosis
Liver Fat Distribution and Quantification

GSI Projection Based Dual Energy

Published in: “Liver fat quantification using fast kVp-switching dual energy CT.”
Kriston et al.
Proc. SPIE 7962, Medical Imaging 2011
Liver Fat Quantification with DECT

Liver Iron Overload

Published in: "Dual-Energy CT for Patients Suspected of Having Liver Iron Overload: Can Virtual Iron Content Imaging Accurately Quantify Liver Iron Content?"
Luo et al.
Radiology Vol. 277, No. 1: 95-103
©RSNA, 2015
Liver Iron Overload

Published in: "Dual-Energy CT for Patients Suspected of Having Liver Iron Overload: Can Virtual Iron Content Imaging Accurately Quantify Liver Iron Content?"
Luo et al.
Radiology Vol. 277, No. 1: 95-103
©RSNA, 2015
Liver Fibrosis Quantification with DECT

Published in: "Material Separation Using Dual-Energy CT: Current and Emerging Applications"
©RSNA, 2016
Response to Focal Therapy
Post TACE Assessment

TACE 70keV

TACE VNC
Virtual Non-Contrast
Dual Energy Monochromatic Imaging: HCC

VNC

Iodine Only
Virtual Unenhanced

Water Only

MSI

Arterial Phase (50 keV)
Metal Artifact Reduction
Dual Energy Metal Artifact Suppression

Metal 77 keV

Metal 140 keV
Dual Energy Metal Artifact Suppression

77 keV  140 keV
Dual Energy Metal Artifact Suppression

140 keV windowed
Dual Energy Workflow
## Exam and Post-Processing Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DECT</th>
<th>SECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise Index (0.625 mm slice)</td>
<td>N/A</td>
<td>36 - 41</td>
</tr>
<tr>
<td>Detector Collimation (mm)</td>
<td>0.625</td>
<td>0.625</td>
</tr>
<tr>
<td>Scan FOV (cm)</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Recon Slice Thickness/Interval (mm)</td>
<td>2.5/2.5</td>
<td>2.5/2.5</td>
</tr>
<tr>
<td>Pitch</td>
<td>1.375:1</td>
<td>1.375:1</td>
</tr>
<tr>
<td>Gantry Rotation Time (sec)</td>
<td>0.5 - 1.0</td>
<td>0.5 - 0.8</td>
</tr>
<tr>
<td>Tube Voltage (kVp)</td>
<td>80/140 fast kVp switching</td>
<td>100 - 120</td>
</tr>
<tr>
<td>Tube Current Control</td>
<td>Modulated based on GSI preset protocol choice</td>
<td>Automatic Exposure Control</td>
</tr>
<tr>
<td>mA Range</td>
<td>375 - 600</td>
<td>200 - 700</td>
</tr>
<tr>
<td>Noise Reduction</td>
<td>ASIR 70%</td>
<td>ASIR 70%</td>
</tr>
</tbody>
</table>
What goes to PACS?

- Best CNR and lesion conspicuity at 50 keV
- Best image quality (lowest noise) at 70 or 77 keV.
  - Will look like 100 or 120 kVp imaging
- May see a few more very subtle hyperenhancing lesions than with single energy viewed at very narrow windows or with iodine color overlay
DE Workflow for Liver CT

- Inject usual amount of iodinated contrast, rate
- Scan late arterial and delayed phases with DECT
  - Select rotation time and preset protocol to match patient radiation dose of a simulated single energy CT in same patient (or a bit higher? – patient specific)
- Post process DECT data into single keV image sets at 50 and 70 or 77 keV plus iodine overlay – send these to PACS
- View in PACS at routine and narrow windows
Postprocessing Hints and Tips:

• If it can be done at the scanner, it should be
  • Can add ASIR there, most direct, single step
• Have your routine reconstructions for the keV levels and image planes automated in scanner
  • Standardized naming of series
• Send data file to AW (server or stand alone)
  • Backup on PACS
  • Measurements
Dual Energy CT: Potential Liver Applications

- Enhance the subtle lesion
- Tumor versus cyst
- Focal fat, iron, fibrosis
- Response to Y-90 and ablation
- Virtual unenhanced
- Artifact reduction
- Workflow