DUAL ENERGY of the Pancreas

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Liver and Pancreas

- Opportunities to improve?
  - Focal lesions: identify early stage tumors, characterize cystic lesions
- Identify material characteristics of tissues: early pancreatic necrosis
- Reduce contrast use, reduce artifacts (metal)
- Assess early response to therapy (non-anatomic)
Dual-Source Dual-Energy MDCT of Pancreatic Adenocarcinoma: Initial Observations With Data Generated at 80 kVp and at Simulated Weighted-Average 120 kVp

OBJECTIVE. The purpose of this study was to determine whether the conspicuity of malignant tumors of the pancreas at dual-source dual-energy CT is better with 80-kVp acquisition than with 120-kVp acquisition simulated with a weighted average.

MATERIALS AND METHODS. Fifteen patients with pancreatic adenocarcinoma underwent contrast-enhanced dual-source dual-energy CT. The abdominal diameter of all patients was 35 cm or less. Data were reconstructed as a weighted average of the 140- and 80-kVp acquisitions, simulating 120 kVp, and as a pure 80-kVp data set. A region-of-interest approach was used to calculate the contrast-to-noise ratio and attenuation off-
- Dual Source: 90° offset of separate 80 kVp and 140 kVp beams
  - Beam hardening
  - Smaller FOV for second beam

**Material decomposition and monochromatic images in IMAGE SPACE**
dsDECT Pancreatic Adenocarcinoma

Dual-Source Dual-Energy MDCT of Pancreatic Adenocarcinoma: Initial Observations With Data Generated at 80 kVp and at Simulated Weighted-Average 120 kVp

<table>
<thead>
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<th>Patient No.</th>
<th>Tumor Attenuation (HU)</th>
<th>Pancreatic Attenuation (HU)</th>
<th>Difference (HU)</th>
<th>CNR</th>
<th>Tumor Attenuation (HU)</th>
<th>Pancreatic Attenuation (HU)</th>
<th>Difference (HU)</th>
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Macari et al. AJR 2010
Single Source

- Standard MDCT images (polychromatic)
- 140, 80 kVp beams
  - Single fast switching source
  - Near-simultaneous acquisition data sets at 140 and 80 kVp
  - Single fast response Garnet gemstone detector

Simulated Monochromatic Images in PROJECTION SPACE
Spectrum of Monoenergetic Images

- Monochromatic (one color) x-ray energy

kVp ~ keV
80  60
100  70
120  77
140  86

keV specifies the photon energy for a monochromatic x-ray source

- 80 kVp
- 140 kVp

kVp defines the upper limit x-ray for a polychromatic x-ray beam

Matsumoto K. Radiology 2011
Dual Energy in Daily Practice

- Multiphasic Pancreas exams
- Pancreatic Mass
- PPP 80 140 kVp
- PVP 120 kVp
- CU 120 kVp
- 70-78 keV
- To PACS
- GSI Viewer
What’s it look like?

- **ssDE scanner**

  Gemstone Spectral Image (GSI) Viewer (0.625mm)

  Routine PACS (2.5mm)

  ≈100-120kVp
Pancreatic Adenocarcinoma

Gemstone Spectral Image (GSI) Viewer

- “Monochromatic” image simulates single energy level (keV)
- Spectral HU curves - greater degree of separation of tumoral and nontumoral pancreas attenuation at lower keV
Pancreatic Adenocarcinoma

50 keV

70 keV

80 keV

100 keV

310 HU

130 HU

147 HU

64 HU

107 HU

44 HU

63 HU

24 HU
Pancreatic Adenocarcinoma

Gemstone Spectral Image (GSI) Viewer

- Energy level can be optimized based on contrast to noise ratio (CNR) between tumoral and nontumoral pancreas

Window/Level 400/40 for both
Panc AdenoCa: Initial Observations

- 64 subjects with panc adeno
- Lesion conspicuity evaluated on GSI viewer at 3 energies:

<table>
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<th>70 keV</th>
<th>CNR-opt keV</th>
<th>45 keV</th>
<th>p value</th>
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<td>Mean conspicuity</td>
<td>55 HU</td>
<td>112 HU</td>
<td>145 HU</td>
<td>0.0005</td>
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<tr>
<td>Nontumoral - tumoral</td>
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<tr>
<td>Mean tumor length</td>
<td>3.6cm</td>
<td>3.3cm</td>
<td>3.1cm</td>
<td>0.026</td>
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Morgan et al RSNA 2010
Implications

- Mean conspicuity increase between 70 keV and CNR-optimized keV was 57 HU
- Median CNR-optimized viewing keV = 50
- Viewing at low (but not lowest) keV on GSI viewer may:
  - Identify non-contour altering isoattenuating masses
  - Depict tumor borders for resectability prediction
Noncontour-altering Panc Adeno

keV=70

keV=49

W/L=400/40

W/L=465/79
So, can it help......?

- Early pancreatic necrosis versus IEP?
So, can it help......?

- Early pancreatic necrosis versus IEP?

Measure Iodine

Iodine image
So, can it help......?

- Early pancreatic necrosis versus IEP?
Cystic Pancreatic Lesions

Routine PACS (2.5mm)
70-78 keV≈100-120kVp

Gemstone Spectral Image (GSI) Viewer (0.625mm)

Sidebranch IPMN
Selecting ROI for CNR optimization

Gemstone Spectral Image (GSI) Viewer

- Select similar density material for CNR optimization
- Filters can be applied “French”
Cystic Panc Masses: Initial Observations

- Compared lesion nodules and septations at two energy levels:
  - 70 keV, CNR-opt keV
  - With and without filter
- 47 patients, mean tumor 3.8 cm
- Optimized keV: mean 51 keV
- More septations were visualized at CNR-opt keV (14.9%) and with filter (74.5%)
- More nodules were seen at CNR-opt keV (10.6%) and with filter (19.1%)
- CNR-opt keV plus filter resulted in highest increase for visualization of septations (91.5%) and nodules (25.5%)
- Pathological diagnosis available for:
  - 11 IPMN, 3 MCN, 4 SCA, 2 PC

Cunningham et al ARC 2011
## Results

<table>
<thead>
<tr>
<th>Type of lesion</th>
<th>Mean nodules 78</th>
<th>Mean nodules CNR-opt keV</th>
<th>Mean nodules 78 plus filter</th>
<th>Mean nodules CNR-opt keV plus filter</th>
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<tbody>
<tr>
<td>MCN (3)</td>
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<td>0.33</td>
<td>1.67</td>
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<td>IPMN (11)</td>
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<td>0.55</td>
<td>1.00</td>
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<td>SCA (4)</td>
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<td>0.50</td>
<td>0.75</td>
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<tr>
<th>Type of lesion</th>
<th>Mean septations 78</th>
<th>Mean septations CNR-opt keV</th>
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<th>Mean septations CNR-opt keV plus filter</th>
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Qualitative Eval of Cyst Contents

keV=70

Stomach HU -10
Cyst HU + 5

keV=70

Stomach HU -2
Cyst HU +28

keV=52

Sidebranch IPMN
Panc Adeno Rx
Paclitaxel and Gemcitabine
Summary

- Observations on ssDE suggest improved ability to detect lesions is possible at lower viewing energies using spectral MDCT
- Optimize to individual pt, or use ≈ 50 keV
- Qualitative information and semi-quantitative information is available on independent workstation
- Material decomposition applications interesting
- Much more work needed!