Automated EMR Dose History Extraction and Monitoring

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Brigham and Women’s Hospital
Harvard Medical School
Disclosures

- Consultant, Siemens
- Consultant, Medrad
Objectives

• Highlight the need for radiation dose history extraction, and desired functionality

• Demonstrate tools for automated EMR extraction of radiation exposure data

• Outline quality / patient safety use-case examples

• Describe use of this data for longitudinal patient-centric dose monitoring
A Drop in the Bucket
Incremental risk argument

Exam indications - shades of gray

Episodic care decisions ⇒ cumulative risk vs cumulative benefit
What Can We Do?
Dose Reduction Opportunities

1. **Before Scan** - *Reduce Drip Rate*
   - Imaging algorithms, evidence based imaging
   - Decision support: appropriateness, radiation risk
   - Non-ionizing alternatives? Ultrasound, MRI

2. **During Scan** - *Reduce Drop Size*
   - Dose-optimized protocols - find the sweet spot
   - Lowest exposure appropriate for the clinical scenario
   - Robust, diagnostic quality exams

3. **After Scan**
   - Capture patient / exam specific exposure information
   - Convert to patient dose using anatomy, size

4. **Continuous**
   - Longitudinal dose & risk monitoring in EMR
EMR Dose Extraction: Why Do It?

- **Scientific**
  - Test / refine models of biological effects at low dose
- **Regulatory oversight**
  - Equipment & practice performance
- **Organization / Institution**
  - Benchmarking, quality improvement, patient safety
- **Equipment / Scanner**
  - Quality assurance, technique optimization
- **Patient**
  - Longitudinal dose monitoring, risk assessment
  - Better informed decision making
EMR Dose Extraction: Desired Features

- All sites of care
- All modalities / sources of exposure
- Modality-specific exposure / technique metrics
- Accurate patient-centric dosimetry
- Standardized database format
- All systems connected!
EMR Dose Extraction: Current Reality

• Fragmented EMRs, not connected
  – Hospital-centric, not patient-centric

• Independent modality-specific efforts
  – Different exposure metrics, platforms
  – CT, fluoroscopy

• Missing important data elements
  – Exposure metrics ⇒ dose

• Data access is limited
  – Inaccessible format (screen captures, text reports)
  – Buried in disconnected systems
**NEED**: Validated Risk Models

Reproduced from:
NEED: Validated Risk Models

• Need better data in the low dose regime to DIRECTLY test the dose-response curve

• Need ACCURATE dosimetry in large number of patients to detect increased cancer incidence above 42% baseline

• Informatics methods for large-scale dose capture ⇒ testing of underlying risk models
NEED: Better Patient- and Exam-Specific Dosimetry

- Capture of modality specific exposure metrics
  - CTDI_{vol}, DLP
- Conversion to patient dose estimates
  - Link to exposed anatomy
  - Correct for patient size

1. McCollough, Leng, Yu, Cody, Boone, McNitt-Gray. *CT Dose Index and Patient Dose: They are NOT the Same Thing*. Radiology (2011) 259; 311-316
GE Dose Screen

<table>
<thead>
<tr>
<th>Series</th>
<th>Type</th>
<th>Scan Range (mm)</th>
<th>CTDIvol (mGy)</th>
<th>DLP (mGy·cm)</th>
<th>Phantom cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scout</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Scout</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>200</td>
<td>Axial</td>
<td>S223.250–S223.250</td>
<td>4.72</td>
<td>2.36</td>
<td>Body 32</td>
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<tr>
<td>3</td>
<td>Helical</td>
<td>S348.250–S13.250</td>
<td>25.72</td>
<td>980.67</td>
<td>Body 32</td>
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<tr>
<td>3</td>
<td>Helical</td>
<td>S519.000–S284.000</td>
<td>10.90</td>
<td>306.58</td>
<td>Body 32</td>
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</table>

Total Exam DLP: 1289.61

Siemens Dose Screen

### Toshiba Dose Screens

**Patient Name (Country):**
**Patient Name (Multi-byte):**

<table>
<thead>
<tr>
<th>ID :</th>
<th>Study ID :</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth Date :</td>
<td>Age : 41Y</td>
</tr>
<tr>
<td>Sex : F</td>
<td>Weight(kg) :</td>
</tr>
<tr>
<td>Height(cm) :</td>
<td>Patient Comments :</td>
</tr>
<tr>
<td>Study Date : 2010.10.19</td>
<td>Body Part : CHEST</td>
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<tr>
<td>Requesting Department :</td>
<td></td>
</tr>
<tr>
<td>Referring Physician :</td>
<td></td>
</tr>
<tr>
<td>Reporting Physician :</td>
<td></td>
</tr>
<tr>
<td>Operator Name : DO</td>
<td></td>
</tr>
<tr>
<td>Total Image Number : 1987</td>
<td></td>
</tr>
</tbody>
</table>

**Dose Information**

- CTDivol (mGy) (Head) : -
- CTDivol (mGy) (Body) : 51.80
- DLP(mGycm) (Head) : -
- DLP(mGycm) (Body) : 978.50

**Contrast/Enhance Information**

- Contrast Enhance : 100 ML ULTRAVIST WATER PREP

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Philips Dose Screen/Sequence

There are many years of exposure data in existing image archives.

Exposing Exposure: Automated Anatomy and Dose Extraction from PACS

- Screen Capture
- Dose Reports
- PACS
- GROK
- MULTIDIMENSIONAL DATA

Graphs showing data from various sources:
- Cancer Center
- Community Hospital
- Main Hospital
- Outside

Graphs with categories:
- Total
- Abdomen/Pelvis
- Head
- Chest
- Neck

NAS/IOM 12/08/2011
GROK
Generalized Radiation Observation Kit

• Name from RA Heinlein, *Stranger in a Strange Land*

• Code extended from David Clunie’s open source PixelMed DICOM Toolkit

• Optical Character Recognition (OCR) of dose report screens, combined with image DICOM attributes

• Extracts CT exposure metrics $\text{CTDI}_{\text{vol}}$ and DLP

• Automatically assigns the exposed anatomy

http://www.brighamandwomens.org/Research/labs/cebi/GROK/
GROK Validation

Institutional Benchmarking

Exposure Distribution of Abdomen/Pelvis CT by Performing Site

CT Protocol Quality Control

### CT Protocol Quality Control

#### Baseline Protocols vs. Performed Examination
- **Institution**: DFCI
- **Protocol RADXT**: Abdomen and Pelvis
- **GROK Anatomy**: Abdomen and Pelvis
- **Protocol Name Combined**: 01_ABDOMEN_WITH

#### Encounters
- Total Encounters: 217
- DE w/DLP: 217

#### Frequency
- Max DLP Distribution
- DLP Var by Pt Weight

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**NAS/IOM 12/08/2011**
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CT Protocol Quality Control

Institution
- Rad
- DFCI
- Foxboro
- Other

Protocol RADXT
- Abdomen, Pelvis, Brain

GROIK Anatomy
- Abdomen and Pelvis
- Abdomen
- Chest, Abdomen and Pelvis
- Extremity
- Pelvis
- Other

Protocol Name Combined
- 01_ABDO_PEL_WTH
- 01_ABDO_PEL_WITH
- 01_ABDOMEN_WTH
- 01_CHEST_WO
- 01_PANC_MASS
- CHEST_CT, CEREBRAL(5.0MMICD364)
- RENAL_MASS
- 02_80KV_PEL_ABD_PEL
- 01_80KV_PEL_ROUTE
- Chest VCT Scan (5.0mm x 64)
- 01_LOW_DOSE_CHEST
- 01_HEAD_TRAUMA
- Chest / Abdomen / Pelvis
- 01_HEAD_WOOUT

DLP Var by Pt Weight

Frequency
Max DLP Distribution
Details
Patient-Centric Longitudinal “Dose” Monitoring

Patient-Centric Longitudinal “Dose” Monitoring

75 Year Old Man with Recurrent Imaging for Hepatocellular Carcinoma and Intracranial Aneurysm


Radiation Exposure from Medical Imaging in the United States of America

- Computed Tomography (CT) ⇒ GROK
- Nuclear Medicine ⇒ PARSE
- Interventional Procedures
- Diagnostic Radiographic and Fluoroscopic Studies

GROK = General Radiation Observation Kit
PARSE = Perl Automation for Radiopharmaceutical Selection & Extraction

http://www.brighamandwomens.org/Research/labs/cebi/GROK/
http://www.brighamandwomens.org/Research/labs/cebi/PARSE/
PARSE
Perl Automation for Radiopharmaceutical Selection & Extraction

“...IV administration of *14 mCi and 31 mCi of Tc-99m Sestamibi* at rest and during peak stress, respectively…”

1) ...of 14 mCi and 31 mCi of Tc-99m Sestamibi at...
2) ...of 14 mCi and 31 mCi of Tc-99m Sestamibi at...
3) ...of 14 mCi and 31 mCi of Tc-99m Sestamibi at...

14 mCi Tc-99m Sestamibi

4) ...of 14 mCi and 31 mCi of Tc-99m Sestamibi at...
5) ...of 14 mCi and 31 mCi of Tc-99m Sestamibi at...
6) ...of 14 mCi and 31 mCi of Tc-99m Sestamibi at...

31 mCi Tc-99m Sestamibi

# tracers: 1 1 >1                Combined
# injections: 1 >1 >1 >1

<table>
<thead>
<tr>
<th>Procedure</th>
<th># Tracers</th>
<th># Injections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone Scan</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Tc-99m MDP</td>
<td>1</td>
<td>&gt;1</td>
</tr>
<tr>
<td>Rest / Stress cardiac</td>
<td>&gt;1</td>
<td>&gt;1</td>
</tr>
<tr>
<td>Tc-99m sestamibi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V/Q scan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xe-133 / Tc-99m MAA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Dose Calculations

Organ Dose = (mCi) * (37) * (conversion factor)

Effective Dose = \( \sum_T [(\text{Organ Dose}) \times (W_T)] \)


Cumulative Doses, Breast Cancer Patient

Acknowledgements

NIH - National Library of Medicine:
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Cami Farkas
Bobby Bransfield
Dick Hanson

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