Out-of-field dose reconstructions for studies of health risks following photon radiotherapy when DICOM-RT are NOT available
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Agenda

1. Kaiser Breast cancer survivors study
   - Overview of cohort
   - Radiogenic health risks of interest
2. Exposure assessment goals
3. Obstacles…
Kaiser case-control study of breast cancer patients

- Substantial improvements in breast cancer survival, combined with increasing incidence rates have resulted in **3 million breast cancer survivors in the US**; 20% of all cancer survivors.

- The long-term health of these women is a clinical and public health concern, with an estimated **10% developing a second cancer by ten years after diagnosis**.

- Radiotherapy results in a reduction of breast cancer mortality 15 years after treatment; However, studies also demonstrated that **radiotherapy increases cardiovascular mortality and second cancer risks**, particularly for women with left-sided breast cancer.
Kaiser case-control study of breast cancer patients

- We aim to examine the relationship between radiotherapy techniques and risks for 2nd cancers and cardiovascular events using an established cohort.

- A nested CC study from ~12,000 breast patients treated at three Kaiser centers
  - Over 9k treatment summaries abstracted thus far from NW, CO
  - Treated between 1990 to 2010
Dosimetry for epidemiologic purposes

- Radiation doses received by individuals from medical exposures are often not recorded and must be reconstructed from exposure information.

- Radiation doses must be **specific to each organ under study**
  - Contralateral breast, lung, heart, and esophagus.

- To make realistic estimates of organ doses requires an understanding of the clinical exposure, radiologic technology and the physics it is based on.
Dosimetry for epidemiologic purposes

- **Individualized dosimetry is not possible** due to limited resources and a lack of information in the medical records.
Dosimetry for epidemiologic purposes

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- We must therefore use **averaged imaging parameters** that are collectively defined from measurement data, computational modeling, literature, and RT treatment summaries (no DICOM-RT).
Existing dosimetry methods for radiotherapy patients

- MD Anderson Cancer Center method\(^1\)
  - Comprehensive 3D dose measurements within a water phantom
  - Age-specific computational phantoms superimposed on the dose matrices
  - Structure of the phantoms based on anatomy textbooks

- Limited to conventional radiotherapy techniques

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Dosimetry of Kaiser case-control study

- In this study, **CT images are not retrievable** from the hospitals and we know dose distribution and treatment planning to be highly affected by patient morphometry.

- We established a **surrogate patient cohort for dosimetry** with the University of Michigan.

- We will then use that information in conjunction with the radiotherapy summaries as the basis for our calculations using NCIRT.
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<thead>
<tr>
<th>Dosimetry Plan</th>
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</thead>
<tbody>
<tr>
<td>Patient anatomy</td>
</tr>
<tr>
<td>Treatment plans</td>
</tr>
<tr>
<td>Dosimetry method</td>
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</tbody>
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Dosimetry of Kaiser case-control study

- 200 Female breast cancer patients (100 left breast, 100 right breast) – stratified by BMI
- Treated at the University of Michigan, Ann Arbor, MI
- Between 2014 – 2015
Dosimetry of Kaiser case-control study

- Treatment planning data (beam energy, prescriptions, gantry angle, collimator angle and sizes, MLC block shapes, 3D dose distribution)
Dosimetry of Kaiser case-control study

- Radiation doses must be **specific to each organ under study**
- Other organs (out-of-field) of based on second cancers reported in cohort:
  - Colon
  - Ovaries
  - Corpus uteri
  - And pancreas… for now

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Dosimetry of Kaiser case-control study

- **Varian Clinac LINAC: 6MV, 16(15)MV**
  - Two field tangents w/ MLC heart-blocks
  - Field-in-field technique (instead of physical wedges)
  - Dose calculations were done with Varian AAA v13.6 algorithm

- **Treatment Planning System (Varian AAA v13.6 algorithm)**
  - Several papers indicating TPS not accurate for **out-of-field** and **heterogeneous** regions
  - TPS reported to underestimate measurements or Monte Carlo dose\textsuperscript{1,2}


Needs of Kaiser case-control study

- Clinical beam data and measurements to validate and implement a virtual source model of clinical accelerators
  - Among the CC cohort, ~30% of patients treated with 4 MV and ~10% at 23 MV
  - Phase-space data files (IAEA-compliant phase space calculations)
- Modeling of radiotherapy compensators and wedges
  - Used in ~50% of cohort and of these we have wedge information for 75%
  - Physical wedges, enhanced dynamic wedges, virtual wedge (Siemens)
- Special treatment techniques (e.g., IMRT in later years)