Big Data: How VHA Can Be Your Friend

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Disclosure

• Vice President, Center for the Assessment of Radiological Sciences (CARS)
  – A non-profit organization dedicated to improving quality and safety of radiotherapy and radiological imaging.
Objectives

• Discuss value proposition in radiation oncology,
• Discuss why VHA is a good test laboratory for determining value in radiation oncology,
• Describe VHA’s Radiation Oncology Practice Assessment (ROPA) initiative,
• Discuss how ROPA can potentially become a model for quality and outcome assessment in radiation oncology.
Value in care defined for the radiation oncologist
Stakeholder in the discussion of value in oncology
What is big data?

- Big data is a term for data sets that are so large or complex that traditional data processing application softwares are inadequate to deal with them. (Wiki)

- Big data is a term that describes the large volume of data – both structured and unstructured. Big data can be analyzed for insights that lead to better decisions and strategic business moves. (SAS)

- Extremely large data sets that may be analyzed computationally to reveal patterns, trends, and associations. (Dictionary)

“5 V”; Volume, Velocity, Variety, Veracity, and Value
The Surveillance, Epidemiology, & End Results (SEER) Registries

- Includes approximately 28% of US Population
- Representative sample of all ethnicities and socio-economic backgrounds

**Limitations**
- Limited information about key health factors
- Inaccuracy; such as under ascertainment of outpatient treatments,
- Migration/loss to follow-up
- Sparse to no RT data

States included in SEER Registries; SEER 9, 13 & 18
Big Data in Cancer Care

From Presentation by Todd McNutt, JHU @Target-Insight, Toronto Ca, 2015

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Big data Challenges in Radiation Oncology

“siloed” data elements
Veteran Health Administration

- Largest Integrated Health care system in United States.
  - 1,233 health care facilities
  - Incl. 168 VA Medical Centers
  - 1,053 outpatient clinics
- Serving more than 8.9 million Veteran each year.
- Annual budget: $69 billion (2017)
- Single interconnected electronic medical record system (VISTA - CPRS) since 1983
VHA Radiation Oncology Centers

40 Centers in 18 regions across the U.S.
Radiation Oncology in VHA

- 40 Radiation Oncology VA clinics
  - 15,000 patients treated in-house
  - 25,000 patient sent outside for RT.
  - 70+ treating radiation oncologists
  - 70+ therapeutic medical physicists
  - 72 linear accelerators

- Longitudinal history of patients RT episode in Vista/CPRS.
Time Points for Data Collection

Consult
Demographics
Diagnosis
Staging
Baseline Tox
Baseline QoL
History

Weekly On Treatment
Toxicity
QoL
Patient status
Symptom Mgmt

End of Treatment
Acute toxicity
QoL
Patient status
Symptom mgmt
Disease response

Follow Up
Late toxicity
QoL
Patient status
Disease response

At what time point do we have enough data to make decision based on future prediction?

Input Variables => Prediction?

From Presentation by Todd McNutt, JHU
@Target-Insight, Toronto Ca, 2015
Purpose: Assessment of radiation delivery and cancer related outcomes for the VHA radiation oncology practices

Background: Disease-site expert panels of the American Society for Radiation Oncology (ASTRO) have identified clinical measures and associated data fields to assess the quality of radiation treatments.

- These clinical measures will be used by the VHA to monitor the quality of radiation oncology and outcome assessment.
  - Pilot: Prostate and Lung Cancer
Scope of Data Acquisition

• **Manual abstraction** by visit to 40 VA Radiation Oncology Centers.

• Comprehensive evaluation of **50 cases from each center**, 20-30 ASTRO vetted metrics per case
  
  – **20 cases** - prostate cancer: T1c – T3, NX0M0 (Intermediate or high risk per NCCN criteria)
  
  – **20 cases** - Non-Small Cell Lung Cancer (NSCLC): Stages IIIA and IIIB
  
  – **10 cases** - Small Cell Lung Cancer (SCLC): Limited Stage.

• Most recent, serial cases in each category who have completed post-treatment follow-up examination
Data Collection for ROPA

Data Sources

– Clinical data
  - Abstracted from physicians clinical note templates in CPRS used by clinicians in their routine process of care
– Radiation treatment management data
  - Abstracted from RT-EMR (e.g. ARIA, MOSAIQ)
– Treatment Planning Data
  - DICOM/DICOM-RT data abstracted from treatment planning systems (e.g. Eclipse, Pinnacle, XiO, Hi-ART...)

Data Abstraction Requirements

– No Protected Health Information (PHI) will be recorded.
– Treatment dates to be recorded as elapsed time from offset.
Clinical Measures
Defined by ASTRO Disease Site Expert Panels

• Quality Measures
  – Measures with published data that will be utilized for the practice assessment.

• Aspirational Measures
  – VA asked the panels to also provide ambitious goals or items not currently in common practice that reflect high quality.
  – Examples: Quality of life assessment prior to treatment completion, Survivorship Care Plans.

• Surveillance Measures
  – Measures that either do not yet have enough published data to demonstrate a link to quality (i.e. collection of molecular information) or are focused on population health (enrollment on clinical trials).
# MEASURE #3: Imaging/Staging for High Risk

| Numerator Statement | Patients with imaging for staging, prior to the initiation of treatment, that includes:  
|                     | 1. CT or MRI, **AND**  
|                     | 2. Bone scan (T⁹⁹ or NaF PET). |
| Denominator Statement | All patients, regardless of age, with a diagnosis of prostate cancer, at high **OR** very high risk as defined by NCCN guidelines, receiving radiation therapy |
| Denominator Exclusions/Exceptions | • Patients treated post prostatectomy |
| Notes | • Consensus Survey Results: 100% |
| Expected Performance Rate | • Higher = better  
|                         | • Panel Vote: 95%  
|                         | • CMS PQRS Measure #102 (Avoidance of Overuse of Bone Scan for Staging Low-Risk Prostate Cancer Patients). Average Performance Rate in 2011: 95.4%. in 2012: 92.9%; in 2013: 90.6% |
| Timeframe | Prior to first treatment |
DVH Metric Types

• **Constraint**
  – Metric will be used to evaluate the plan and provider’s performance

• **Informational**
  – For the purposes of data collection
  – **Not** to be used to judge the appropriateness of a plan

• **DVH Metric Scale**
  – Most DVH Constraints and DVH Informational Metrics were divided into a 3 tiered system
  – **Green**: Pass
  – **Yellow**: Warning
  – **Red**: Fail
Lung Quality Measures
# Spinal Cord Dmax* Metrics

## Varying Fractionation

<table>
<thead>
<tr>
<th>Limit</th>
<th>Green</th>
<th>Yellow</th>
<th>Red</th>
<th>Mandatory Constraint vs. Informational</th>
<th>Source</th>
<th>Fractionation</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 Gy</td>
<td>&lt;= 45 Gy</td>
<td>&gt;45 Gy &lt;= 50 Gy</td>
<td>&gt;50 Gy</td>
<td>Constraint</td>
<td>QUANTEC</td>
<td>Standard</td>
</tr>
<tr>
<td>41 Gy</td>
<td>&lt;= 36.9 Gy</td>
<td>&gt;36.9 Gy &lt;= 41 Gy</td>
<td>&gt;41 Gy</td>
<td>Constraint</td>
<td>Turrisi, NEJM 1998, RTOG 0538</td>
<td>Hyper</td>
</tr>
<tr>
<td>37 Gy</td>
<td>&lt;= 33.3 Gy</td>
<td>&gt;33.3 Gy &lt;= 37 Gy</td>
<td>&gt;37 Gy</td>
<td>Constraint</td>
<td>BED calc (aB = 3, EQD2 = 49.6 Gy)</td>
<td>Hypo - 10</td>
</tr>
<tr>
<td>42 Gy</td>
<td>&lt;= 37.8 Gy</td>
<td>&gt;37.8 Gy &lt;= 42 Gy</td>
<td>&gt;42 Gy</td>
<td>Constraint</td>
<td>Timmerman / USC, confirmed w/BED (aB = 3, EQD2 = 48.7 Gy)</td>
<td>Hypo - 15</td>
</tr>
</tbody>
</table>

*Dose to <0.035 cc*
# Various Lung Metrics

## Standard Fractionation

<table>
<thead>
<tr>
<th>Metric</th>
<th>Limit</th>
<th>Green</th>
<th>Yellow</th>
<th>Red</th>
<th>Mandatory Constraint vs. Informational</th>
<th>Source</th>
<th>Note*</th>
</tr>
</thead>
<tbody>
<tr>
<td>V20 Gy</td>
<td>37%</td>
<td>&lt;= 33%</td>
<td>&gt; 33% &lt;= 37%</td>
<td>&gt; 37%</td>
<td>Constraint</td>
<td>QUANTEC</td>
<td>2 lungs</td>
</tr>
<tr>
<td>V5 Gy</td>
<td>60%</td>
<td>&lt;= 54%</td>
<td>&gt; 54% &lt;= 60%</td>
<td>&gt; 60%</td>
<td>Informational</td>
<td>RTOG 1308</td>
<td>2 lungs</td>
</tr>
<tr>
<td>Dmean</td>
<td>20 Gy</td>
<td>&lt;= 18 Gy</td>
<td>&gt; 18 Gy &lt;= 20 Gy</td>
<td>&gt; 20 Gy</td>
<td>Informational</td>
<td>QUANTEC</td>
<td>2 lungs</td>
</tr>
<tr>
<td>V20 Gy</td>
<td>7%</td>
<td>&lt;= 6.3%</td>
<td>&gt; 6.3% &lt;= 7%</td>
<td>&gt; 7%</td>
<td>Constraint</td>
<td>Rice et al, IJROBP 2007</td>
<td>1 lung</td>
</tr>
<tr>
<td>V5 Gy</td>
<td>60%</td>
<td>&lt;= 54%</td>
<td>&gt; 54% &lt;= 60%</td>
<td>&gt; 60%</td>
<td>Informational</td>
<td>Allen et al, IJROBP 2007</td>
<td>1 lung</td>
</tr>
<tr>
<td>Dmean</td>
<td>8.5 Gy</td>
<td>&lt;= 7.7 Gy</td>
<td>&gt; 7.7 Gy &lt;= 8.5 Gy</td>
<td>&gt; 8.5 Gy</td>
<td>Constraint</td>
<td>Rice et al, IJROBP 2007</td>
<td>1 lung</td>
</tr>
</tbody>
</table>

*Total Lung - XXX. In order of availability, GTV>ITV>CTV>PTV
# Esophagus Metrics

**Standard Fractionation**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Limit</th>
<th>Green</th>
<th>Yellow</th>
<th>Red</th>
<th>Mandatory Constraint vs. Informational</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>V60 Gy</td>
<td>17%</td>
<td>&lt;= 15.3 %</td>
<td>&gt; 15.3% &lt;= 17 %</td>
<td>&gt; 17%</td>
<td>Informational</td>
<td>Palma et al, IJROBP 2014</td>
</tr>
<tr>
<td>Dmean</td>
<td>34 Gy</td>
<td>&lt;= 30.6 Gy</td>
<td>&gt; 30.6 Gy &lt;= 34 Gy</td>
<td>&gt; 34 Gy</td>
<td>Informational</td>
<td>QUANTEC</td>
</tr>
<tr>
<td>Dmax*</td>
<td>74 Gy</td>
<td>&lt;= 66.6 Gy</td>
<td>&gt; 66.6 Gy &lt;= 74 Gy</td>
<td>&gt; 74 Gy</td>
<td>Informational</td>
<td>RTOG 1308</td>
</tr>
</tbody>
</table>

* Dose to <0.035 cc
# Other Metrics

## Standard Fractionation

<table>
<thead>
<tr>
<th>OAR</th>
<th>Metric</th>
<th>Limit</th>
<th>Green</th>
<th>Yellow</th>
<th>Red</th>
<th>Mandatory Constraint vs. Informational</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brachial Plexus</td>
<td>Dmax*</td>
<td>66 Gy</td>
<td>&lt;= 59.4 Gy</td>
<td>&gt; 59.4 Gy &lt;= 66 Gy</td>
<td>&gt; 66 Gy</td>
<td>Constraint</td>
<td>QUANTEC</td>
</tr>
<tr>
<td>Heart</td>
<td>V45Gy</td>
<td>35%</td>
<td>&lt;= 31.5%</td>
<td>&gt; 31.5% &lt;= 35%</td>
<td>&gt; 35%</td>
<td>Informational</td>
<td>RTOG 1308</td>
</tr>
<tr>
<td>PTV</td>
<td>D95%</td>
<td>100% Rx</td>
<td>100%</td>
<td>&gt;= 95% &lt; 100%</td>
<td>&lt; 95%</td>
<td>Constraint</td>
<td>RTOG 1308</td>
</tr>
<tr>
<td>PTV</td>
<td>Dmin*</td>
<td>85% Rx</td>
<td>&gt;85%</td>
<td>&gt;= 75% &lt; 85%</td>
<td>&lt; 75%</td>
<td>Informational</td>
<td>RTOG 1308</td>
</tr>
</tbody>
</table>

* Dose to <0.035 cc
Prostate Quality Measures
## Rectum Metrics

### External Beam, Varying Fractionation

<table>
<thead>
<tr>
<th>Metric</th>
<th>Limit</th>
<th>Green</th>
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<th>Red</th>
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<th>Source</th>
<th>Fractionation</th>
</tr>
</thead>
<tbody>
<tr>
<td>V70 Gy*</td>
<td>25%</td>
<td>&lt;=25%</td>
<td>&gt;25%</td>
<td></td>
<td>Constraint</td>
<td>RTOG 0126, 0415, 0815</td>
<td>Standard</td>
</tr>
<tr>
<td>V69 Gy</td>
<td>25%</td>
<td>&lt;=25%</td>
<td>&gt;25%</td>
<td></td>
<td>Informational</td>
<td>RTOG 0415</td>
<td>Hypo</td>
</tr>
<tr>
<td>V70 Gy</td>
<td>15%</td>
<td>&lt;=15%</td>
<td>&gt;15%</td>
<td></td>
<td>Informational</td>
<td>Michalski et al, IJROBP 2013</td>
<td>Standard</td>
</tr>
<tr>
<td>V75 Gy</td>
<td>10%</td>
<td>&lt;=10%</td>
<td>&gt;10%</td>
<td></td>
<td>Informational</td>
<td>Michalski et al, IJROBP 2013</td>
<td>Standard</td>
</tr>
<tr>
<td>V50 Gy</td>
<td>50%</td>
<td>&lt;=50%</td>
<td>&gt;50%</td>
<td></td>
<td>Constraint</td>
<td>QUANTEC</td>
<td>Standard</td>
</tr>
</tbody>
</table>

*Should be met in >= 90% of cases*
# Bladder, Femurs Metrics

**External Beam, Standard Fractionation**

<table>
<thead>
<tr>
<th>OAR</th>
<th>Metric</th>
<th>Limit</th>
<th>Green</th>
<th>Yellow</th>
<th>Red</th>
<th>Mandatory Constraint vs. Informational</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder*</td>
<td>V70 Gy</td>
<td>35%</td>
<td>&lt;=35%</td>
<td></td>
<td>&gt;35%</td>
<td>Informational</td>
<td>QUANTEC, RTOG 0126, 0415, 0815</td>
</tr>
<tr>
<td>Bladder</td>
<td>V65 Gy</td>
<td>50%</td>
<td>&lt;=50%</td>
<td></td>
<td>&gt;50%</td>
<td>Informational</td>
<td>QUANTEC, RTOG 0126, 0415, 0816</td>
</tr>
<tr>
<td>Femurs</td>
<td>V50 Gy</td>
<td>10%</td>
<td>&lt;=10%</td>
<td></td>
<td>&gt;10%</td>
<td>Informational</td>
<td>RTOG 0534</td>
</tr>
</tbody>
</table>

*Should be met in >= 90% of cases*
# Bowel Metrics

**External Beam, Standard Fractionation**

<table>
<thead>
<tr>
<th>OAR</th>
<th>Metric</th>
<th>Limit</th>
<th>Green</th>
<th>Yellow</th>
<th>Red</th>
<th>Mandatory Constraint vs. Informational</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder</td>
<td>V70 Gy</td>
<td>35%</td>
<td>&lt;=35%</td>
<td>&gt;35%</td>
<td>Informational</td>
<td>QUANTEC, RTOG 0126, 0415, 0815</td>
<td></td>
</tr>
<tr>
<td>Bladder</td>
<td>V65 Gy</td>
<td>50%</td>
<td>&lt;=50%</td>
<td>&gt;50%</td>
<td>Informational</td>
<td>QUANTEC, RTOG 0126, 0415, 0816</td>
<td></td>
</tr>
<tr>
<td>Femurs</td>
<td>V50 Gy</td>
<td>10%</td>
<td>&lt;=10%</td>
<td>&gt;10%</td>
<td>Informational</td>
<td>RTOG 0534</td>
<td></td>
</tr>
</tbody>
</table>

*Volume is Bladder minus CTV*
VHA ROPA Workflow
VHA ROPA

**Deliverables**

- **Facility reports**: detailed radiation delivery parameters and outcomes, nationally benchmarked for 50 cases
- **VHA global report**: examines variability within VHA

  - Benefit to the VHA enterprise: Roadmap for continuous improvement for each in-house radiation oncology practice
  - Identification of metrics for future internal, remote evaluations using VA’s EMR (CPRS)

**Parallel Effort**

Electronic abstraction of data fields for clinical measures directly from different data sources and performing periodic remote electronic re-assessment.
VHA ROPA

**Data Sources**

- **Clinical data**
  - Abstracted from disease-site specific clinical note templates in CPRS used by clinicians in their routine process of care
- **Radiation treatment management**
  - Abstracted from RT-EMR (e.g. ARIA, MOSAIQ)
- **Treatment Planning Data**
  - DICOM/DICOM-RT data abstracted from treatment planning systems
- **Patient Reported Outcome data from Patient Portals**

**Electronic Data Abstraction**

- Deployment of the data aggregation software at the local facility
  - Aggregation of data at various time points in the treatment process
  - Data integrity, completeness and validation check
- Deployment of the Enterprise Central QA Database
  - Aggregate data from all VA facilities.
  - Tools for data analysis, national benchmarking and analysis of variability within VHA
Abstraction of Patient Specific Data elements for Practice Assessment

[IT Infrastructure]

VA’s Nationwide Intranet network

VA Intranet based QA Database

VA’s Corporate Data Warehouse

Internet based server

Patient Portal

Radiation Oncology Patient Reported Outcomes Module
Disease Site Specific “Smart” Templates in Radiation Oncology

- Consensus clinical templates for all major disease sites treated with RT,
- Initial consultation, treatment planning, treatment, end of treatment, and follow up notes,
- Designed to prepopulate data from CPRS’s patient chart and subsequent notes seamlessly.
Disease Site Specific “Smart” Templates in CPRS

Clinical Templates with Discrete Codified Data Elements
Data abstracted from Consult template used to prepopulated Treatment planning template
Work Flow Templates in CPRS
Abstraction of Patient Specific Data elements for Practice Assessment
[IT Infrastructure]

VA's Nationwide Intranet network

VA - Richmond

Diagnostic Imaging (CT/AMR/PET)

RT-EMR / TMS
(Tx Delivery – Linac)

RT-TPS
(Tx Plan)

QA Devices

CPRS

VA - East Orange

VA - Miami

VA - Long Beach

HINGE Software

Data Archival

Data entry forms

Check for completeness

Data Integrity Check

Encrypt data

Compress data

Display Statistics

Facility Report Card

Data abstractive from disease site templates

Data abstractive from Web based forms

Secure Web Service Connection

VA Intranet based RO warehouse

RO Database

Data uploaded / downloaded

Web Services

VA's Corporate Data Warehouse

VA's Firewall

Internet based server

DB

Patient Portal

Radiation Oncology
Patient Reported Outcomes Module

* HINGE - Health Information Gateway and Exchange Application
Summary

• Quality care is one of the dominant issues in health care today, especially in radiation oncology,
• Quality care data are most complex in radiation oncology but structured,
• Quality of care is best assessed from the perspective of structure, process, and outcome measures.
• VHA is leading the nation in establishing an electronic infrastructure that will automatically abstract data from clinical workflow templates to assess the quality of radiotherapy and outcomes.