AAPM TG 263: The Benefits of Standardizing Radiation Therapy Nomenclature

AAPM Spring Clinical Meeting March 20, 2017

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Disclosures

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Outline

• Why Big Data’s hasn’t give us big gains yet
• Life before TG 263
• Goals of TG 263
• Sample draft recommendations
• Leveraging Big Data as a Community
Do we know what we have in our databases so that we can assemble the information or tools into something meaningful?

Can we find what we need?

Sorting helps

Can we then build what we need?
Are we organizing the data we care about into “rows” so that we can automate harvesting it later?

Charles Mayo
Need clarity in communication among team members + systems: target, non-target, dose volume histogram metrics

Much of the information we need is linked to dose volume histograms ... stored in our Treatment Planning Systems
Inspect your own data...you’ll see variations over time, treatment planners, physicians, treatment planning systems.

Plan for Lung Patient 1

Patient 2

Patient 3

Patient 4

Look across multiple institutions ... You’ll find much wider variation.
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Have we standardized our data and how we share it?

• We purchase treatment planning systems (TPS) from a limited number of vendors
• But, we have different workflows and other computer systems
  – CT scanners, image registration software
  – Multiple datasets & times – adaptive plan, replan from previous treatment
  – How do we handle serial vs parallel organs with respect to changes in patient anatomy?
• We often have our own way of doing things…not just by institution but by physicist, dosimetrist, clinician
## Previous Standardization Efforts

### Table 2. Planning organs at risk volumes

<table>
<thead>
<tr>
<th>Organ at risk name</th>
<th>Left/right</th>
<th>Margin (mm)</th>
<th>Proposed name</th>
</tr>
</thead>
<tbody>
<tr>
<td>SpinalCord</td>
<td>N/A</td>
<td>Nonuniform</td>
<td>SpinalCord_PRV</td>
</tr>
<tr>
<td>SpinalCord_PRV</td>
<td>N/A</td>
<td>5</td>
<td>SpinalCord_05</td>
</tr>
<tr>
<td>Parotid</td>
<td>Left</td>
<td>0</td>
<td>Parotid_L</td>
</tr>
<tr>
<td>Parotid</td>
<td>Right</td>
<td>0</td>
<td>Parotid_R</td>
</tr>
<tr>
<td>Total parotid</td>
<td>Left+Right</td>
<td>0</td>
<td>Parotids</td>
</tr>
<tr>
<td>Kidney</td>
<td>Left</td>
<td>10</td>
<td>Kidney_L_10</td>
</tr>
</tbody>
</table>

To reap benefits of

- Automated tools to extract data for trials and Clinical Practice Improvement
- Automated safety checks
- Automated planning
- Comprehensive outcomes databases
- Better plan evaluation tools

We have to overcome inconsistencies in

- Structure names
- Laterality indicators
- Constraints of vended systems
- DVH metrics
- Contouring descriptors
- ....

Previous methods of addressing the inconsistencies in structure names have involved making duplicate structures with the clinical name vs the clinical trial name or mapping structures.
What can we do with Big Data?

• The University of Michigan is the coordinating center for a statewide registry focused on breast and lung cancer which we launched in 2012.

• Focused registry:
  – Patient and physician reported outcomes
  – Photos for patients who consent
  – Physics/dosimetry details

• 25 institutions:
  – Community and academic centers represented
  – Thousands of patients

• There are a number of ongoing analyses related to technology use, target coverage, …
User uploads data for each structure based on the label in the MROQC Database. The nomenclature was prior to TG 263 efforts.

Variability in Rates of Hypofractionation for Eligible Patients with Breast Cancer in Michigan


What is the rate of utilization of breath hold control for breast and lung cancer patients?

n = 2392 patients

n = 1035 patients

"The TRIAD system includes built-in functions that can be used to automate digital data QA during the transmission process. In particular, it includes an automated evaluation of the consistency between the submitted structure names and protocol requirements."

<table>
<thead>
<tr>
<th>Prescription Structures</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A_Aorta_CTV</td>
<td>Used to construct CTV for Pancreatic studies.</td>
</tr>
<tr>
<td>A_Celliac_CTV</td>
<td>Used to construct CTV for Pancreatic studies.</td>
</tr>
<tr>
<td>A_SupMea_CTV</td>
<td>Used to construct CTV for Pancreatic studies.</td>
</tr>
<tr>
<td>CT1GTV</td>
<td>Adaptive - GTV based on initial CT scan</td>
</tr>
<tr>
<td>CT1PT1CTV</td>
<td>Adaptive - CTV based on initial CT and PET scan</td>
</tr>
<tr>
<td>CT1PT1GTV</td>
<td>Adaptive - GTV based on initial CT and PET scan</td>
</tr>
<tr>
<td>CT1PT1PTV</td>
<td>Adaptive - PTV based on initial CT and PET scan</td>
</tr>
<tr>
<td>CT2GTV</td>
<td>Adaptive - GTV based on interim CT scan</td>
</tr>
<tr>
<td>CT2PTV</td>
<td>Adaptive - PTV based on interim CT scan</td>
</tr>
</tbody>
</table>
Outline

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• Life before TG 263
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• Leveraging Big Data as a Community
TG 263 - Standardizing Nomenclature for Radiation Therapy: Creating Group Consensus

- Group of 57 stakeholders
- Domestic and international groups
- Broad range of perspectives represented

<table>
<thead>
<tr>
<th>Roles</th>
<th>Professional Societies</th>
<th>Clinic Types</th>
<th>Specialty Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physician</td>
<td>ASTRO</td>
<td>Academic</td>
<td>IHE-RO</td>
</tr>
<tr>
<td>Physicist</td>
<td>AAPM</td>
<td>Community</td>
<td>DICOM Working Group</td>
</tr>
<tr>
<td>Vendor</td>
<td>ESTRO</td>
<td>Large Practice</td>
<td>NRG</td>
</tr>
<tr>
<td>Dosimetrist</td>
<td>AAMD</td>
<td>Small Practice</td>
<td>IROC</td>
</tr>
</tbody>
</table>
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• Sample draft recommendations
• Leveraging Big Data as a Community
Current Status AAPM TG263

• The report is under a 2nd review by Therapy Physics Committee after approval by the Work Group on Clinical Trials and QA & Outcome Subcommittee

• Emphasis for the report is on non-target structures and DVH nomenclature and rules for targets

• Good participation from a radiation therapy clinical trials perspective – members from IROC-Houston and IROC-Philadelphia and NRG
## Sample Recommendation for Non-Target Structure Names

<table>
<thead>
<tr>
<th>Structure names limited to ≤16 characters</th>
<th>Compatibility with multiple vendor systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unique regardless of capitalization</td>
<td>Prevent conflicts in the database</td>
</tr>
<tr>
<td>First character of the structure category is capitalized</td>
<td>Femur_Head, Ear_Externals</td>
</tr>
<tr>
<td>Spatial categories for the primary name are at the end of the string: Lung_LUL</td>
<td>Standard for interpretation</td>
</tr>
<tr>
<td>Two allowed names for each structure: e.g. Read right to left or left to right; Kidney_R or R_Kidney</td>
<td>Some systems allow for longer strings but may only display 16 characters; want to see correct structure name without ambiguity; Two methods gives users flexibility to choose one.</td>
</tr>
</tbody>
</table>
### Sample Recommendation for Non-Target Structure Names

<table>
<thead>
<tr>
<th>Sample Recommendation for Non-Target Structure Names</th>
<th>Reasoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use tilde to indicate partial structures, e.g. Lungs vs Lungs~</td>
<td>For example when a CT scan may be cut off. Flags incomplete data automatically.</td>
</tr>
<tr>
<td>Underscore character to separate categorization</td>
<td>Bone_Pelvic</td>
</tr>
<tr>
<td>For structures not used in prescription dose constraints, put a ‘z’ in front of the structure</td>
<td>Allows for alphabetic sorting to minimize confusion in a clinical setting; valuable in the post-treatment analysis setting!</td>
</tr>
</tbody>
</table>

In our clinic these ‘z’ labeled structures are applied to structures which aid in optimization and for draft resident contours.

- Brainstem
- CTV_5000
- PTV_5000
- zD95%
- zHot
- zOptPTV5000
Sample of Proposed Guiding Principles for Non-Target Nomenclature

Allow two standard names for each structure. Reading Left->Right:

1) Categorizes from General -> Specific  preferred default

   *Alphabetic sort groups structure categories, Lung_R, Lung_L, Lungs*

2) Categorizes from Specific -> General

   *Better safety for limited character displays in some systems*

   \[\text{L\_OpticNrv} \quad \text{OpticNrv\_L}\]
TG263 – Tested during development!

- We had multiple participants pilot the TG263 nomenclature as we were developing the rules
  - Multiple vendor settings and clinical environments
- Manufacturer stakeholders at the table
- Clinical trial representation at the table
Report Includes a sortable spreadsheet of standardized names including FMAID labels where they exist.

Connection to other ontologies where they exist is valuable.
Target Nomenclature: First set of characters must be one of following allowed target types

- GTV
- CTV
- ITV
- IGTV (Internal GTV, i.e. gross disease with margin for motion)
- ICTV (Internal CTV, i.e. clinical disease with margin for motion)
- PTV
- PTV!: For low dose PTV volumes that exclude overlapping high dose volumes (See section discussing segmented vs non-segmented PTVs)
Target Nomenclature: If dose is indicated, it’s at the end of the target string prefixed with an underscore character

- Numeric values are in cGy, e.g. GTV_5400, CTV_5400, PTV_5400*

- Text values define relative dose levels
  - High : e.g. PTV_High, CTV_High, GTV_High
  - Low : e.g. PTV_Low, CTV_Low, GTV_Low
  - Intermediate : e.g. PTV_Intermediate
  - Mid+2 digit enumerator: allows specification of more than 3 relative dose levels e.g. PTV_Low, PTV_Mid01, PTV_Mid02, PTV_High

The Value of Looking at Our Data: Prescriptions alone are not enough

Fig. 2. Frequency distribution of ICRU-83 dose parameters. N=5094 patients; D95% has a peak at 1.

Fig. 5. Dose parameters versus treatment techniques. Minimal variations in IMRT vs VMAT.

Das et al, PRO 7: 2017.
Standardizing Dose Volume Histogram Nomenclature

- Input & Output units
- High & Low dose metrics
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Goal: Improve patient care by connecting radiation therapy Big Data to other Big Data

<table>
<thead>
<tr>
<th>Key Element Category</th>
<th>Demand Ranking</th>
<th>ETL Difficulty</th>
<th>Typical Source Systems</th>
<th>Access</th>
<th>Multiple Source Systems</th>
<th>Use of Used Free Text Entry</th>
<th>Missing Data</th>
<th>Data Accuracy</th>
<th>Lack of Standardization</th>
<th>PHI Constraints</th>
<th>Limit Access</th>
<th>Legacy Formats or Systems</th>
<th>Require Process Changes</th>
<th>Extensive Transformation</th>
<th>Other</th>
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<tr>
<td>Demographics</td>
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<td>E, X</td>
</tr>
</tbody>
</table>

Other Efforts: University of Michigan Radiation Oncology Analytics Resource (M-ROAR) – Led by Check Mayo

Use Cases Drive Prioritization of Development of Input ETLs, M-ROAR Schema, and Architecture Supporting Reporting, Research & Collaboration

ETL Source Systems
- Radiation Oncology Information System (ARIS)
- Treatment Planning System (CaféP)
- Electronic Health Record (EHR)
- Health System Data Warehouse
- Legacy Systems
- Spreadsheets
- PMS System

ETL Issues
- Access to server systems
- Missing data or inconsistent entry
- Changes over time in format, quality, detail
- Unstructured Free Text
- Inconsistent nomenclature
- Challenges detailing needed relationships to other elements
- Manual effort needed in extraction
- Extensive processing of raw data needed

ETL Status
- Existing processes work
- Making processes changes to allow automated extractions
- In development

Data Type | Source System | ETL Issues | ETL Status
---|---|---|---
Demographics | | | 
Lab | | | 
Medications | | | 
Survival | | | 
Health info (e.g., smoking status) | | | 
Encounters (Office Visits, Emergency, Hospitalizations) + diagnosis codes | | | 
Toxicity – Provider Reported | | | 
Patient Reported Outcomes | | | 
Resonance | | | 
Pathology | | | 
Surgery | | | 
Chemotherapy Treatment Details | | | 
Radiation Treatment Details | | | 
Prescription | | | 
Diagnosis and Imaging | | | 
TX Imaging and Timeline Details | | | 
DNA Curves | | | 
DNA Metrics | | | 
Imaging | | | 
Radiomics | | | 
Genomics | | | 
Historic Research Results | | | 

Processing/Cleanup Algorithms

Reduce information entropy with each transformation step

Tableau Server

Use Case Specific Queries

Tableau Self-Service Dashboard
- Per patient details
- Population summary graphics
- Multi-factor identifiers for cohorts

Supporting Specific Retrospective Research Projects

Developing Collaborative Multi-institutional Studies

Developing Multi-institutional Distributed Learning Models (e.g., EuroCAT, MeerCAT)

Charles Mayo – M-ROAR
• Can analyze a wide range of dosimetric, treatment, labs, diagnostic, hospital encounters and other data ... to look for interactions.

• Standardize, Curate, Aggregate…USE!

Patient characteristics such as age, location, gender, ...

Charles Mayo – M-ROAR
Any dose metric can be queried and plotted for any existing structure.

Charles Mayo – M-ROAR

Generalized Evaluation Metric: Allows comparison against the requested MD value as well as the patient population results.
Summary

• There is substantial knowledge and efficiency to be lost by not creating and using standardization as part of our daily clinical practice

• Standardization lowers cost and increases the quality of data that can be automatically extracted
  – Treatment Planning System
  – Radiation Oncology Information System
  – Electronic Health Record

• TG-263 Nomenclature in use in many centers enabling creation of software improving clinical processes and learning

• Paves the way for future ontology developments and in sharing with other ontologies too!
  – Makes our sandbox bigger and more valuable to our patients!
Acknowledgments

• Charles Mayo – Chair of TG263
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  – John Yao, PhD
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  – Dan McShan, PhD
  – Issam El Naqa, PhD
  – Grant Weyburn
  – Lynn Holevinski
  – Carlos Anderson, PhD
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