Clinical applications of structured databases in radiation therapy

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This is NOT a Cloud

Nomograms
Designed for data sharing

Types of data in radiotherapy

Structured data standards

<table>
<thead>
<tr>
<th>Structured data standards</th>
<th>Types of data in radiotherapy</th>
<th>Designed for data sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td>DICOM RT</td>
<td>Radiation Plans</td>
<td></td>
</tr>
<tr>
<td>ICD9 (10)</td>
<td>Diagnosis</td>
<td></td>
</tr>
<tr>
<td>ICD 0</td>
<td>Morphology</td>
<td></td>
</tr>
<tr>
<td>CTCAE</td>
<td>Toxicity</td>
<td></td>
</tr>
<tr>
<td>AJCC</td>
<td>Staging</td>
<td></td>
</tr>
<tr>
<td>LOINC</td>
<td>Labs/Measures</td>
<td></td>
</tr>
<tr>
<td>RxNorm</td>
<td>Medications</td>
<td></td>
</tr>
<tr>
<td>CPT</td>
<td>Procedures/Billing</td>
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</tr>
</tbody>
</table>
# Treatment Timeline

- **Simulation**
  - Demographics
  - Image Guidance
- **Planning**
  - Treatment Targets
  - OARs
  - OVH
- **Weekly**
  - Toxicity
  - Chart
- **End of Treatment**
  - Acute Toxicity
  - Patient Status
  - Symptom Mgmt
- **Follow Up**
  - Late Toxicity
  - QoL
  - Disease Response

# Data Collection in Clinic

- **Clinical Assessment**
  - Quality of life
  - Disease Status

# Extract, Transform, Load

- **MOSAIQ**
  - SQL Query
  - Lab, Toxicity, Assessments
- **Oncospace**
  - Scripts, Python, DICOM
  - DVH, OVH, Shapes
- **Pinnacle TPS**
  - Lab, Toxicity, Assessments
Types of databases

- Relational databases
  - SQL based
  - Tables and their relationships
- Object or document oriented databases
  - XML Databases
  - NoSQL

Database Table Design
(Key-Value)

- While there are many types of medical data, there is a much smaller number of classes of medical data (i.e. PSA, K, Her2/Neu are all lab tests)

<table>
<thead>
<tr>
<th>Laboratory Values</th>
<th>TestName</th>
<th>TestValue</th>
<th>TestUnit</th>
<th>TestDate</th>
<th>NormalRangeLower</th>
<th>NormalRangeUpper</th>
<th>Laboratory Location</th>
<th>Laboratory Values Key</th>
<th>PatientIDKey</th>
<th>ClinicalAssessmentKey</th>
<th>DataEntryKey</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSA_VALUE</td>
<td>WBC</td>
<td>CA19-9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Prostate specific antigen 8 12/25/2005

- While there are many types of medical data, there is a much smaller number of classes of medical data (i.e. PSA, K, Her2/Neu are all lab tests)
Use of SQL DB reduces search to an SQL query

Trivial SQL Lesson

```sql
SELECT roi.ID, roi.volume
FROM RegionsOfInterest roi
WHERE roi.name = 'r_parotid'
ORDER BY roi.ID
```

Output

<table>
<thead>
<tr>
<th>ID</th>
<th>Volume</th>
<th>Dose_to_50</th>
</tr>
</thead>
<tbody>
<tr>
<td>2931</td>
<td>47.0198</td>
<td>3257.88</td>
</tr>
<tr>
<td>2975</td>
<td>23.5393</td>
<td>2875.21</td>
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<tr>
<td>3009</td>
<td>24.0458</td>
<td>3056.14</td>
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<tr>
<td>3054</td>
<td>26.6619</td>
<td>3466.96</td>
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<tr>
<td>3080</td>
<td>64.7959</td>
<td>2965.67</td>
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<tr>
<td>3123</td>
<td>40.1324</td>
<td>2864.71</td>
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<tr>
<td>3160</td>
<td>32.7532</td>
<td>3226.49</td>
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<tr>
<td>3230</td>
<td>24.8615</td>
<td>2795.85</td>
</tr>
<tr>
<td>3250</td>
<td>39.3615</td>
<td>6310.66</td>
</tr>
<tr>
<td>3289</td>
<td>24.6493</td>
<td>2858.92</td>
</tr>
<tr>
<td>3315</td>
<td>40.6475</td>
<td>2984.79</td>
</tr>
</tbody>
</table>

Simple SQL Lesson

```sql
SELECT roi.ID, roi.volume, MIN(dvh.X) as dose_to_50
FROM DVHData dvh
INNER JOIN RoiDoseSummaries rds
on rds.ID = dvh.roiDoseSummaryID
INNER JOIN RegionsOfInterest roi
on roi.ID = rds.roiID
WHERE roi.name = 'r_parotid'
and rds.type = 'Cumulative DVH, Norm Volume'
and dvh.Y <= 0.50 -- percent volume
GROUP BY roi.ID, roi.volume
ORDER BY roi.ID
```
**Shape-dose relationship for radiation plan quality**

- More efficient plan optimization (10 fold)
- Normal tissue doses reduced (5-10%)
- Clinically released for Pancreatic Cancer

**Toxicity trends during and after treatment – detect outliers**

- **Dysphagia**
  - Swallowing
  - Worsens after Tx for many patients then improves long term

- **Mucositis**
  - Inflammation
  - Heals after Tx for most patients

- **Xerostomia**
  - Dry Mouth
  - Tends to be permanent

**DVH, Toxicities and Grade distributions**

- Voice Change
- Larynx
- Trachea
- Dysphagia
- Larynx, edema
- Hoarseness
- Vocal Cord

- Number of patients by grade at D50%
Dysphagia and Xerostomia

Larynx vs Grade ≥ 2 Dysphagia

Dysphagia and Xerostomia

Treatment Timeline

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

Summary

- The Oncospace model can house RT data effectively and provides a model for sharing
- Data collection in the clinical environment has been demonstrated
- Decision support to improve quality and safety has been demonstrated
- Personalized medicine has not been fully demonstrated, but remains a tenable goal
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