Design for Care
AAPM 2017
Tue-AB-FS4-0
Outline
Joint Therapy-Imaging Session

• Designing away error. 
  A radiation oncology physicist’s perspective. 
  Eric Ford, PhD

• Human Factors Engineering in Software Interface Design. A Vendor’s Perspective 
  Cristina Negrut, MS
Outline of the session

• Designing the Optimal Reading Room Environment. A Radiology Perspective
  Elizabeth Krupinski, PhD

• Workflow Design and Errors. An Anesthesiologist’s Perspective
  Aubrey Samost-Williams, MD, MS
Designing away error.  
A radiation oncology physicist’s perspective.

Eric Ford, PhD, FAAPM  
Professor  
University of Washington  
Seattle, WA
Disclosures

• AHRQ R18 HS022204-01
• NCI UG3 CA211310-01
Case Study

Error and Design
The lethal overdose of Lisa Norris
January 2006
Beatson Oncology Center, Glasgow, Scotland
References

  [http://www.scotland.gov.uk/Publications/2006/10/27084909/0](http://www.scotland.gov.uk/Publications/2006/10/27084909/0)

- IAEA Training Course 2.10. 
  [https://rpop.iaea.org/RPOP/RPoP/Content/AdditionalResources/Training/1_TrainingMaterial/AccidentPreventionRadiotherapy.htm](https://rpop.iaea.org/RPOP/RPoP/Content/AdditionalResources/Training/1_TrainingMaterial/AccidentPreventionRadiotherapy.htm)
Clinical Background

- Lisa Norris. 15 yo female with pineoblastoma.
- Sept 2005 referred for radiotherapy.
- Intended prescription:
  - 1.75 Gy x 20 (35 Gy) to whole craniospinal axis
  - Spine fields split (upper and lower)
  - Followed by 1.8 Gy x 11 (19.8 Gy) to tumor bed
Background: Planning System

- May 2005. Clinic upgrades to Varis 7. Allow direct transfer of plan Eclipse->Varis *RTChart* module (previously typed in by hand)
- Use of paper forms was retained for some of the more complex cases (e.g. ‘whole CNS’)

Planning for Lisa Norris

- Rx entered in RTChart
- Treatment planning complete in Eclipse
- “Planner B” transcribes dose to paper form.
Planner B entered MU per 167 cGy instead of MU per 100 cGy
Plan checked by two senior planners.
Plan goes on to radiographer.
Following standard calc procedure:
\[ \text{Output (MU/100cGy)} \times \text{Rx (175 cGy)} = 159 \text{ MU} \]
Should have been \textbf{94.5 MU}
Treatment starts January 5.
Dose/fraction = 2.92 Gy instead of 1.75 Gy
Finding the Error

• Feb 1, 2006. Another case is planned by Planner B.
• Same normalization error made.
• Caught by Plan Checker D.
• Realize the mistake in Lisa Norris’ plan.
• Treatment stopped immediately.
Follow Up

• Lisa Norris received 19 fractions
  • 2.92 Gy x 19 = 55.5 Gy
  • vs. intended 1.75 Gy x 20 = 35 Gy
  • 58% overdose
Follow Up

• Lisa Norris died nine months later
Stopping Errors

Quality Control
Stopping Errors
A traditionalist approach
Risk ala TG-100 and FMEA

Risk = S x O x D

AAPM Task Group 100, Huq et al. 2016
“Mock” plan with embedded errors

Error: incorrect isocenter location
Results: Mock Plan Error Checks

Gopan, Ford et al. 2017
Quality Control Using Checks: TG-100

AAPM Task Group 100, Huq et al. 2016
Risk ala TG-100 and FMEA

Risk = S x O x D

AAPM Task Group 100, Huq et al. 2016
Causal Factors Analysis

- Communication
- Human behavior involving staff
- Policies, Procedures, Regulations
- Equipment design and construction issues
- Training
- Other

Spraker et al. Prac Rad Onc, 2017
Could the process / form be designed to prevent error from happening in the first place?

<table>
<thead>
<tr>
<th>Beam Weight (%)</th>
<th>100% (a)</th>
<th>100% (a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output (MU/100cGy)</td>
<td>100% (b)</td>
<td>100% (c)</td>
</tr>
<tr>
<td>Dose Information</td>
<td>T.A.D. mid brain = 100%</td>
<td>spinal cord: %</td>
</tr>
<tr>
<td></td>
<td>Normalisation = ......%</td>
<td>max subcut: ......%</td>
</tr>
</tbody>
</table>
Data-driven design
The RO-ILS mission is to facilitate safer and higher quality care in radiation oncology by providing a mechanism for shared learning in a secure and non-punitive environment.

Launched: June 2014
Cumulative Number of Contracted Practices and Facilities

- Practices
- Facilities
CT in TPS and isocenters
### CT import window

<table>
<thead>
<tr>
<th>Image Name</th>
<th>Modality</th>
<th>MRN</th>
<th>Study ID</th>
<th># of Images</th>
<th>Scan Date/Time</th>
<th>Series Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>CT</td>
<td></td>
<td>5004</td>
<td>58</td>
<td>2013-09-01</td>
<td>PELVIS PUBLIC ARCH</td>
</tr>
<tr>
<td>Multiple CT scans</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Plan document

| Patient Name: |  |
| Patient ID: |  |
| Plan Name: | L5-S2 |
| Trial Name: | L... Approved |
| Revision: | R04.P03.D03 |
| Lock Status: | The plan was locked by  |

**Plan Setup**

| Primary Data Set Name: |  |
| Primary Data Set Dimensions: | 232 slices, 512 x 512 pixels |
| CT to Density Table Name: | CT Sim Aug05 |

| Patient Position: | On back (supine) |
| Couch: | Removed at Y = -10.29 |
| Body Board Angle: | None |

| Number of Photon Beams: | 2 |
| Number of Stereo Beams: | 0 |
| Number of Electron Beams: | 0 |
| Number of Brachy Sources: | 0 |

| Outside-Patient Air Threshold: | 0.60 g/cm³ |

### Dose Grid Geometry

<table>
<thead>
<tr>
<th>Lateral</th>
<th>Art-Post</th>
<th>Sup-Inf</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>0.400</td>
<td>0.400</td>
<td>0.400</td>
</tr>
<tr>
<td>Dimension</td>
<td>119</td>
<td>97</td>
<td>109</td>
</tr>
<tr>
<td>Origin</td>
<td>-23.415</td>
<td>-22.922</td>
<td>-18.840</td>
</tr>
<tr>
<td>Reference Point</td>
<td>-0.00</td>
<td>4.61</td>
<td>0.00</td>
</tr>
</tbody>
</table>

| Top Slice of CT Extended: | 0.00 cm |
| Bottom Slice of CT Extended: | 0.00 cm |

Region of Interest Density Overrides:

R07
Failure Modes

1. Wrong CT scan loaded into TPS
Isocenter Handling

CT sim → Reset (N) → Planner checks → Handoff

Reset (Y) → MD reset → Handoff
Failure Modes

1. Wrong CT scan loaded into TPS
2. Isocenter move after sim not communicated
Simulation Navigator

Patient name: [Redacted]

Patient Setup
Orientation:
- [ ] Verified setup Notes in Mosaiq
- [ ] Breath hold

Isocenter Info
How did you mark the patient at sim:
- Iso marked at sim
- CT origin set at sim
- Used existing marks

Click to close
Conclusions & Future Directions
Further reading
Acknowledgments

Lulu Jordan, (BS)RTT
Lora Holland, (BS)RTT
Patty Sponseller, CMD
Sunshine Gray, RN
Avrey Novak
Tom Mullen, MD
Wendy Gao, MD
Matt Spraker, MD
Michael Gensheimer, MD
Aaron Kusano, MD
Casey Bojechko, PhD
Alan Kalet, PhD
Mark Phillips, PhD
Joshua Carlson
Olga Gopan, PhD
Matt Nyflot, PhD
Jing Zeng, MD
Ralph Ermoian, MD
Gabrielle Kane, MD