The Smart Way to Check Treatment Plans and Charts

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American Association Of Medical Dosimetrists
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Conflicts
NONE

Professional Affiliations
AAPM Liaison to the AAMD
Member, AAPM Subcommittee on Training and Practice of Medical Dosimetry
Member, AAPM Working Group for Prevention of Errors
Member, AAPM TG-275 – Strategies for Effective Physics Plan and Chart Review in Radiation Therapy
Learning Objectives

The participant will be able to:
• Describe FMEA methodology.
• Identify three high-risk failure modes in treatment planning.
• Integrate recommendations of TG-275 in the clinic.
What is FMEA???

**Failure Modes and Effects Analysis**

- Risk Assessment Tool
- Developed in the late 1950’s by reliability engineers
- Identify malfunctions in a process
- Adopted by AAPM TG-100 to provide guidance for QA programs in Radiation Oncology
  - Identify high-risk activities
  - Balance patient safety and quality versus resources
  - Develop a framework for future QA programs
What is FMEA???

Failure Modes and Effects Analysis

1. Choose a **process**
2. Pull together a **team** of individuals invested in the process
3. Work together to **map** out the process
4. Create a **process tree** including sub processes illustrating interrelationships
5. **Evaluate** each step in the process and ask:
   a. What could go wrong?
   b. How could that happen?
   c. What are the causes of the failure?
   d. How likely is the failure to occur?
   e. How hard is to detect the failure before the patient is effected?
   f. What are the effects if the failure goes undetected?
   g. What is the overall risk of each failure mode?
Step #1: Choose a Process

Checking a Treatment Plan
Step #2: Assemble a Team

Medical Physicist

Medical Dosimetrist

Simulation Therapist

Radiation Oncologist

Lead Radiation Therapist
Step #3: Map Out the Process

Checking a Treatment Plan

1. Correct Patient
2. Correct Treatment Site, including Laterality
3. Correct Image Set Used for Planning
4. Accurate Fusion and Contours
5. Correct Protocol Used, including Energy
6. Plan Agrees with Prescription
7. Approvals Present
8. Correct Data Transferred into Information System
9. Imaging Needed for Treatment is Properly Transferred
Step #3: Create A Process Tree

Checking a Treatment Plan

Correct Patient → Correct Treatment Site → Plan Vs. Prescription → Correct CT Used for Planning

Site → Diagnosis → Energy → Prescription Point → Dose → Fractionation

Including Sub-processes and Inter-relationships.
Examples of a Process Trees
Simple Process Tree
Step #5: Evaluate Each Step in the Process

a. What could go wrong? (Potential Failure)
b. How could that happen? (A Failure Mode)
c. What are the causes of the failure mode? (Cause)
d. How likely is the failure mode to occur? (Occurrence = O)
e. How hard is the failure mode to detect before the patient is effected? (Detectability = D)
f. What are the effects if the failure mode goes undetected? (Severity = S)
g. What is the overall risk of the failure mode? (RPN = O * D * S)
# Scales for O, S, D

<table>
<thead>
<tr>
<th>Value</th>
<th>Occurrence</th>
<th>Severity</th>
<th>Detectability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Very unlikely</td>
<td>No adverse effect</td>
<td>Always detected</td>
</tr>
<tr>
<td>2-3</td>
<td>Low probability</td>
<td>Grade 1 (Mild)</td>
<td>High probability of being detected</td>
</tr>
<tr>
<td>4-5</td>
<td>Some probability</td>
<td>Grade 2 (Moderate)</td>
<td>Moderate probability of being detected</td>
</tr>
<tr>
<td>6-7</td>
<td>Moderate probability</td>
<td>Grade 3 (Severe)</td>
<td>Some probability of being detected</td>
</tr>
<tr>
<td>8-9</td>
<td>High probability</td>
<td>Grade 4 (Life Threatening)</td>
<td>Low probability of being detected</td>
</tr>
<tr>
<td>10</td>
<td>Certain Failure</td>
<td>Death</td>
<td>Impossible to Detect</td>
</tr>
</tbody>
</table>
## Identify High Risk Failure Modes

<table>
<thead>
<tr>
<th>Category</th>
<th>Severity</th>
<th>RPN (relative)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No or Very Low Risk (minor inconvenience)</td>
<td>1-2</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Low Risk (mild skin reaction, short delay in care)</td>
<td>3-4</td>
<td>10-100</td>
</tr>
<tr>
<td>Medium Risk (Acute reaction requiring unplanned break, cone down, or boost)</td>
<td>5-7</td>
<td>100-300</td>
</tr>
<tr>
<td>High Risk (Requiring Intervention or Results in Death)</td>
<td>8-10</td>
<td>&gt;300</td>
</tr>
</tbody>
</table>
Process Steps, Failure Modes and Swiss Cheese
The Swiss Cheese Model and Plan Checking

- Importing CT Data Set
- Fusion of PET/CT
- Contouring OARs
- Following Planning Protocol
Prevention of Accidents

2010

The New York Times

Failure Mode: MLC not in place for HN IMRT treatment

Patient Death
• To review existing data and recommendations that support the use of physics plan and chart review; and to review the current recommendations on the qualifications for performing these.

• To provide survey information on current practices in the community with respect to physics plan and chart review.

• To provide risk-based recommendations for the effective use of the following physics review: initial plan and chart check, weekly chart check and end-of-treatment chart check.

• To provide recommendations to software vendors for systems design and operations that best facilitate physics plan and chart review.
Risk-Based Recommendations
Using TG-100 Formulism

- Started with a Process Map
- Performed FMEA
  - Identify failure modes and causes
  - Score each with O, S, D scale
  - Identify high-risk failure modes (high S and RPN)
- Identify causes that are not covered by QM
- Develop QA
Members of the Team

- Eric Ford, Chair, University of Washington
- Lei Dong, Scripps Proton Therapy Center
- Luis Fong de los Santos, Mayo Clinic
- Anne Greener, East Orange VA
- Jennifer Johnson, UT MD Anderson Cancer Center
- Perry Johnson, University of Miami
- Grace Gwe-Ya Kim, University of California, San Diego
- James Mechalakos, Memorial Sloan-Kettering Cancer Center
- Brian Napolitano, AAMD Representative, MGH
- Stephanie Parker, Novant Health
- Deborah Schofield, Saint Vincent Hospital
- Koren Smith, AAPM Professional Council Representative, Mary Bird Perkins Cancer Center
- Michelle Wells, Piedmont Hospital
- Ellen Yorke, Memorial Sloan-Kettering Cancer Center
High Level Process Map

Patient Assessment

Imaging for RT planning

Treatment Planning

Pre-Treatment Review and Verification

Treatment Delivery

On-Treatment Verification

x N Fractions

Post –Treatment Completion

Weekly Chart Reviews

Treatment Plan Review

Equipment and Software Quality Management

EOT Chart Review

Results of FMEA for Plan Checking

• Identified **183** Failure Modes
• 41 (22%) Failure Modes had high severity scores
• 22 (12%) Failure Modes had high RPN values
• 52 (28%) Failure Modes had either high severity or high RPN
Example #1 of O,S,D & RPN
(Detectability during a Plan Check)

* Failure Mode
  * Wrong CT dataset used for planning

* Causes
  * No set procedure for preplan check
  * Miscommunication
  * Wrong scan designated
  * Wrong scan imported

<table>
<thead>
<tr>
<th>O</th>
<th>S</th>
<th>D</th>
<th>RPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>6</td>
<td>4</td>
<td>96</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>3</td>
<td>72</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>6</td>
<td>72</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>5</td>
<td>60</td>
</tr>
</tbody>
</table>

Medium Risk – Use checklist pre-plannning.
Example #2 of O,S,D & RPN
(Detectability during a Plan Check)

* Failure Mode
  * Special preps not performed for simulation (e.g. contrast, bladder or bowel prep)

* Causes
  * Lack of supplies
  * RTT oversight
  * Lack of standard site-specific procedures
  * No MD request
  * Patient did not follow instructions

<table>
<thead>
<tr>
<th>O</th>
<th>S</th>
<th>D</th>
<th>RPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>4</td>
<td>32</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Low Risk – Nothing happened to the patient!
Example #3 of O,S,D & RPN
(Detectability during a Plan Check)

* Failure Mode
  * Plan does not match prescription

* Causes
  * MD inattention
  * MD confused
  * Wrong dose/fractionation
  * Incorrect treatment site
  * Incorrect treatment technique

<table>
<thead>
<tr>
<th></th>
<th>S</th>
<th>D</th>
<th>RPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>8</td>
<td>2</td>
<td>32</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>2</td>
<td>32</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>2</td>
<td>32</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>2</td>
<td>48</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>2</td>
<td>24</td>
</tr>
</tbody>
</table>

High Risk – Which is correct: plan or prescription?
Identify High-Risk Failure Modes

<table>
<thead>
<tr>
<th>Process Step</th>
<th>Failure Mode</th>
<th>O</th>
<th>S</th>
<th>D</th>
<th>RPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Assessment and Treatment Planning</td>
<td>Plan does not match prescription (e.g. wrong energy, dose/# fx, bolus, type of image guidance)</td>
<td>2</td>
<td>8</td>
<td>2</td>
<td>32</td>
</tr>
<tr>
<td>Imaging for RT Planning (Simulation)</td>
<td>Special preps not performed for simulation (e.g. contrast, bladder or bowel prep)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Treatment Planning</td>
<td>Wrong CT dataset used for planning</td>
<td>3</td>
<td>6</td>
<td>5</td>
<td>90</td>
</tr>
</tbody>
</table>
High-Risk Failure Modes

- MD contours are wrong or inaccurate
- Miscommunication about prior dose, pacemaker or pregnancy
- Wrong target dose
- Unable to assess prior dose and current treatment
- Plan incorrectly reviewed by MD
- Plan does not reflect intent (prostate, prostate/SV, prostate/nodes)
- Wrong normal tissue or OAR
- Incorrect laterality
High-Risk Failure Modes

- Treatment devices omitted (bolus)
- Poor registration between imaging studies
- Wrong or inaccurate contours drawn by planner
- QA results misinterpreted
- Improper margins for PTV
- Suboptimal plan
- Confusing instructions for isocenter shift
- Planner not informed of outside images for fusion (PET/CT)
Look for Final Report of TG-275!

• Report current and evolving practices
  * Results of literature review
  * Reflective of the survey

• Publish guidelines based on High-Risk Failure Modes
  * Analysis of FMEA results

• Make recommendations to vendors
  * Adapt systems design and operations to better facilitate physics chart checking
References

* ACR-ASTRO, ACR–ASTRO Practice Parameter for Radiation Oncology, 2014, American College of Radiology: Reston, VA.