Shareable Clinical Pathways in Radiation Oncology Using BPMN and DMN

Gabe Colburn, Founder and CEO Quantek Systems
Raghavendiran Boopathy, Assistant Professor OHSU
Radiation Therapy

Cancer Diagnosis
Radiation Therapy Indicated
Radiation Course
1..N CT/PET/MRI Simulations
1..M Treatment Plans Created
Plan Check/Verification
1..Y Radiation Treatments

Care Team: Radiation Oncologists, Nurses, Medical Physicists, Medical Dosimetrists, Radiation Therapists, Managers, IT

Highly Complex, Technical Treatment with Diverse Care Team
OHSU Current Workflow in Clinic

Patient Check in
- Mosaiq/Email/Pager

Consult/Sim
- Mosaiq/Email/Pager

Contouring
- QCL/Email/Pager/Excel/Phone

Treatment planning
- QCL/Email/Pager/Text/Phone

QA
- QCL/Email/Pager/Text/Phone

Treatment
- Mosaiq/Email/Pager/Phone/Text

Referring/MA/nursing/communication/assigned physician

Protocols, automation (whiteboard), schedules email/text, dosimetrist and physicist don’t have much of an interaction

Physicist not aware of which dosimetrist is working on a plan. Information about contouring during contouring rounds. Hard to focus without knowing who is going to work on the patient plan.

Planning done by the dosimetrist and approved by physician. Many patients re-planned after physicist reviews and finds discrepancies

QA by a totally different physicist/residents/students, radcalc, dose check, Mobius, Perfraction, ArcCheck, MapCheck, Excel, delta4, film, chamber, nanodot, email, email and email

On treatment checks done by different physicist and therapists/person of the day emails the group multiple times regarding any questions regarding the patient
**OHSU Proposed Workflow**

- **Patient Check in**
  - Patient Registered in RO Dynamics and Care Team Assigned

- **Consult/Sim**
  - Core Care Team Discussion

- **Pre-Planning**
  - Rx/Images/Contouring

- **Treatment Planning / Plan Evaluation**
  - Treatment Planning / Plan Evaluation

- **QA**
  - Physics QA/Plan Check

- **Therapist Checks**
  - Therapist Assigned and Pre-Treatment Checks

**BPMN Workflows**

1. **Start Radiation Treatment**
   - Assign Patient Care Team
   - Course Complete

2. **Simulation**
   - Start Simulation
   - Simulation Complete

3. **Radiation Plan & Treatment**
   - Start Plan and Treatment Message
   - Plan and Treatment Complete
OHSU Proposed Workflow

- Patient Check in
  - Patient Registered in RO Dynamics and Care Team Assigned

- Consult/Sim
  - Core Care Team Discussion

- Pre-Planning
  - Rx/Images/Contouring

- Treatment planning
  - Treatment Planning / Plan Evaluation

- QA
  - Physics QA/Plan Check

- Therapist Checks
  - Therapist Assigned and Pre-Treatment Checks

BPMN Workflows

Simulation

Radiation Plan & Treatment

Start Simulation → Simulation Complete

Start Plan and Treatment Message → Plan and Treatment Complete

Start Radiation Course → Assign Patient Care Team

Course Complete in 90 Days → Course Complete

Simulation Complete
OHSU Proposed Workflow

- **Patient Check in**
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- **Treatment Planning**
  - Treatment Planning / Plan Evaluation

- **QA**
  - Physics QA/Plan Check

- **Therapist Checks**
  - Therapist Assigned and Pre-Treatment Checks

BPMN Workflows
OHSU Proposed Workflow

**Patient Walk in**
- Patient Registered in RO Dynamics and Care Team Assigned

**Consult/Sim**
- Core Care Team Discussion

**Pre-Planning**
- Rx/Images/Contouring

**Treatment Planning**
- Treatment Planning / Plan Evaluation/Finalization

**QA**
- Physics QA/Plan Check

**Therapist Checks**
- Therapist Assigned and Pre-Treatment Checks

BPMN Workflows
OHSU Proposed Workflow

- **Patient Check in**
  - Patient Registered in RO Dynamics and Care Team Assigned

- **Consult/Sim**
  - Core Care Team Discussion

- **Pre-Planning**
  - Rx/Images/Contouring

- **Treatment planning**
  - Treatment Planning / Plan Evaluation

- **QA**
  - Physics QA/Plan Check

- **Treatment**
  - Therapist Assigned and Pre-Treatment Checks

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**Treatment Planning Call Activity Example**

![Diagram of Treatment Planning Call Activity Example]
OHSU Proposed Workflow

**Patient Check in**
- Patient Registered in RO Dynamics and Care Team Assigned

**Consult/Sim**
- Core Care Team Discussion

**Pre-Planning**
- Rx/Images/Contouring

**Treatment Planning**
- Treatment Planning / Plan Evaluation/Finalization

**QA**
- Physics QA/Plan Check

**Therapist Checks**
- Therapist Assigned and Pre-Treatment Checks
AAPM TG-203 Report: Management of radiotherapy patients with implanted cardiac pacemakers and defibrillators

"Managing radiotherapy patients with implanted cardiac devices (implantable cardiac pacemakers and implantable cardioverter-defibrillators) has been a great practical and procedural challenge in radiation oncology practice."

<table>
<thead>
<tr>
<th>Patient</th>
<th>Dose region and risk category</th>
<th>Neutrons present</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;2 Gy</td>
<td>2-5 Gy</td>
</tr>
<tr>
<td>Pacing independent</td>
<td>Low risk</td>
<td>Medium risk</td>
</tr>
<tr>
<td>Pacing dependent</td>
<td>Medium risk</td>
<td>Medium risk</td>
</tr>
</tbody>
</table>

CIED Workflow in BPMN/DMN

Patient with CIED and indicated Radiotherapy

- Inform treating cardiologist and inform patient
- Determine patients’ pacing-dependency
- Inform if anti-tachycardia therapy can be switched off by magnet when ICD

- Estimate dose on CIED
  - More than 10 cm from treatment field edge – dose probably <2 Gy
  - Less than 10 cm from field edge – measure to confirm dose
- Within 3 cm from field edge – can rely on TPS calculation
- Minimize dose to CIED with treatment plan optimization

- DOSE ≤ 5 Gy
  - No neutrons
  - Pacing-independent patient and
  - Dose on CIED = < 2 Gy

- DOSE > 5 Gy
  - Neutron-producing therapy

HIGH-RISK
- Medium-Risk AND
  - ECG weekly monitoring
  - Trained staff monitors ECG
  - Cardiologist/pacemaker technician should be available, if needed
  - CIED technologist to interrogate the device weekly once the device receives > 5 Gy.

LOW-RISK
- Nuclotronizations protocol
- Pacemaker magnet, pulse oximetry, and AED available at treatment unit
- Close monitoring of the CIED patient with an audio-visual system during treatment.
- Communication with cardiologist/electrophysiologist.
- ICD patient consult with cardiologist/electrophysiology on setting program tachycardia OFF or the use of magnet.
- CIED interrogation before 1st fraction and after last fraction.

- CIED evaluated by cardiologist/electrophysiology following treatment (at 1 and 6 months).

New CIED Evaluation
CIED Workflow in BPMN/DMN

NEW CIED EVALUATION

Patient with CIED and indicated Radiotherapy

- Inform treating cardiologist and inform patient
- Determine patients’ pacing-dependency
- Inform if anti-tachycardia therapy can be switched off by magnet when ICD

When the tumor is within this zone, the CIED dose could be:

- More than 10 cm from treatment field edge – dose probably <2 Gy
- Less than 10 cm from field edge – measure to confirm dose
- Within 3 cm from field edge – can rely on TPS calculation

Minimize dose to CIED with treatment plan optimization

- Dose < 2 Gy
- Dose > 5 Gy OR Neutron producing therapy

YES

- Pacing-independent patient and Dose on CIED < 2 Gy

NO

LOW-RISK
- Consents lesion protocol
- Pacemaker magnet; pulse oximetry, and AED available at treatment unit
- Close monitoring of the CIED patient with an audio-visual system during treatment.
- Communication with cardiologist/electrophysiologist.
- ICD patients consult with cardiologist/electrophysiologist on setting up arrhythmia OFF or the use of magnet.
- CIED interrogation before 1st fraction and after last fraction.

MEDIUM-RISK
- Low-Risk AND
- Formal consultation with cardiologist/electrophysiologist
- Pacing-dependent: consult with cardiologist/electrophysiologist on the use of magnet and pulse oximetry.
- Appropriate cardiac support available to manage complications from potential CIED malfunctions.
- CIED technician to interrogate the device at mid-treatment.

- CIED evaluated by cardiologist/electrophysiologist following treatment (at 1 and 6 months).

HIGH-RISK
- Medium-Risk AND
- ECG weekly monitoring.
- Time until device interrogation.
- Cardiologist/pacemaker technician should be available, if needed.
- CIED technician to interrogate the device weekly once the device receives > 5 Gy.

NEW CIED EVALUATION

- Patient/CIED Tag Strong
- Terminate CIED Evaluation

Decision:
- Yes
- No

Inform ECG Evaluation
- Patient/CIED Tag Weak
- No

CIED Evaluation
CIED Workflow in BPMN/DMN

CIED Planning Evaluation

- Inform treating cardiologist and inform patient
- Determine patients’ pacing-dependency
- Inform if anti-tachycardia therapy can be switched off by magnet when ICD.

- Estimate dose on CIED
  - More than 10 cm from treatment field edge – dose probably <2 Gy
  - Less than 10 cm from field edge – measures to confirm dose
  - Within 3 cm from field edge – can rely on TPS calculation
- Minimize dose to CIED with treatment plan optimization

- Pacing-independent patient and
- Dose on CIED < 2 Gy

LOW-RISK
- Reassurance protocol.
- Pacemaker magnet, pulse oximetry, and AED available at treatment unit.
- Close monitoring of the CIED patient with an audio-visual system during treatment.
- Communication with cardiologist/electrophysiologist.
- ICD patients consult with cardiologist/electrophysiologist on setting program tachycardia OFF or the use of magnet.
- CIED interrogation before 1st fraction and after last fraction.

MEDIUM-RISK
- Low-Risk AND
  - Formal consultation with cardiologist/electrophysiologist
  - Pacing-dependent: consult with cardiologist/electrophysiologist on the use of magnet and pulse oximetry.
  - Appropriate cardiac support available to manage complications from potential CIED malfunctions.
- CIED technologist to interrogate device weekly once the device receives > 5 Gy.

HIGH-RISK
- Medium-Risk AND
  - ECG weekly monitoring.
  - Trained staff examines ECG.
  - Cardiologist/pacemaker technologist should be available, if needed.
- CIED technologist to interrogate device weekly once the device receives > 5 Gy.

- CIED evaluated by cardiologist/electrophysiologist following treatment (at 1 and 6 months).
CIED Workflow in BPMN/DMN

Patient with CIED and indicated Radiotherapy

- Inform treating cardiologist and inform patient
- Determine patients' pacing-dependency
- Inform if anti-tachycardia therapy can be switched off by magnet when ICD.

When the tumor is within this zone, the CIED dose could be:

- Estimate dose on CIED
  - More than 10 cm from treatment field edge – dose probably <2 Gy
  - Less than 10 cm from field edge – measure to confirm dose
  - Within 3 cm from field edge – can rely on TPS calculation
- Minimize dose to CIED with treatment plan optimization

Dose ≤ 6.5 Gy
- No neutrons

Dose > 6.5 Gy
- Neutron producing therapy

- Pacing-independent patient and
  - Dose on CIED < 2 Gy

LOW-RISK
- Brainstem lesions protocol
- Pacemaker magnet, pulse oximeter, and AED available at treatment unit
- Close monitoring of the CIED patient with an audio-visual system during treatment
- Communication with cardiologist/electrophysiology
- ICD patient: consult with cardiologist/electrophysiology on setting program tachycardia OFF or the use of magnet
- CIED interrogation before 1st fraction and after last fraction

MEDIUM-RISK
- Low-risk AND
  - Formal consultation with cardiologist/electrophysiology
  - Pacing-dependent: consult with cardiologist/electrophysiology on the use of magnet and pulse oximeter
  - Appropriate cardiac support available to manage complications from potential CIED malfunctions
  - CIED technician to interrogate the device at mid-treatment

HIGH-RISK
- Medium-risk AND
  - Cardiologist/pacemaker technician should be available, if needed
  - CIED technician to interrogate the device weekly once the device receives > 5 Gy

What is the Estimated Dose to the CIED?

- Distance of CIED to Field Edge
- Treatment Planning System Dose

What is the Patient CIED Risk Level?

- Neutron Producing Therapy
- Pacing Dependency

AAPM TG-203 Report
CIED Workflow in BPMN/DMN

CIED Planning Evaluation

What is the Estimated Dose to the CIED?

<table>
<thead>
<tr>
<th>CIED Estimated Dose</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIED Distance to Field Edge (cm)</td>
<td>integer</td>
<td>integer</td>
</tr>
<tr>
<td>TPS Estimated Dose (cGy)</td>
<td>integer</td>
<td>integer</td>
</tr>
<tr>
<td>CIED Estimated Dose (cGy)</td>
<td>integer</td>
<td>boolean</td>
</tr>
<tr>
<td>CIED Measurement Required</td>
<td>boolean</td>
<td></td>
</tr>
</tbody>
</table>

1. Dose > 50 Gy OR Neutron producing therapy
2. No

What is the Patient CIED Risk Level?

<table>
<thead>
<tr>
<th>Patient CIED Risk</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIED Estimated Dose (cGy)</td>
<td>integer</td>
<td>boolean</td>
</tr>
<tr>
<td>Neutron Producing Therapy</td>
<td>boolean</td>
<td>boolean</td>
</tr>
<tr>
<td>Pacing Independent</td>
<td>boolean</td>
<td>string</td>
</tr>
<tr>
<td>Risk</td>
<td>string</td>
<td></td>
</tr>
</tbody>
</table>

1. <200
2. 200.000
3. >500
4. -

CIED Estimated Dose (cGy):
- Low-Risk
  - No complications protocol.
  - Pacemaker magnet/pulse oximetry, and AED available at treatment unit.
  - Close monitoring of the CIED patient with an audio-visual system during treatment.
  - Communication with cardiology/electrophysiology.
  - ICD patients consult with cardiology/electrophysiology on setting program tachycardia OFF or the use of magnet.
  - CIED interrogation before 1st fraction and after last fraction.

- Medium-Risk
  - Formal consultation with cardiology/electrophysiology.
  - Pacing-dependent: consult with cardiology/electrophysiology on the use of magnet and pulse oximetry.
  - Appropriate cardiac support available to manage complications from potential CIED malfunctions.
  - CIED technologist to interrogate the device weekly once the device receives > 5 Gy.

- High-Risk
  - ECG weekly monitoring.
  - Trained staff examines ECG.
  - Cardiologist/pacemaker technologist should be available, if necessary.
  - CIED technologist to interrogate the device weekly once the device receives > 5 Gy.

- CIED evaluated by cardiology/electrophysiology following treatment (at 1 and 6 months).
CIED Workflow in BPMN/DMN

Patient with CIED and indicated Radiotherapy

- Inform treating cardiologist and inform patient
- Determine patients' pacing dependency
- Inform if anti-tachycardia therapy can be switched off by magnet when ICD.

When the tumor is within this zone, the CIED dose would be:

- Dose > 5 Gy
- Neutron producing therapy
- Pacing-independent patient and Dose on CIED < 2 Gy

Dose 15.5 Gy
No neutrons

Estimate dose on CIED
- More than 10 cm from treatment field edge — dose probably <2 Gy
- Less than 10 cm from field edge — measures to confirm dose
- Within 3 cm from field edge — can rely on TPS calculation
- Minimize dose to CIED with treatment plan optimization

HIGH-RISK
- Medium-Risk AND
  - ECG weekly monitoring.
  - Trained staff evaluates ECG.
  - Cardiologist/pacemaker technologist should be available, if needed.
  - CIED technologist to interrogate the device weekly once the device receives > 5 Gy.

LOW-RISK
- No neutrons
- No pacing
- No pacing-dependent therapy and Dose on CIED < 2 Gy

MEDEDIUM-RISK
- High-Risk AND
  - Formal consultation with cardiology/electrophysiology
  - Pacing-dependence: consult with cardiologist/electrophysiology on the use of magnet and pulse oximetry.
  - Appropriate cardiac support available to manage complications from potential CIED malfunction.
  - CIED technologist to interrogate the device at mid-treatment.

- CIED evaluated by cardiology/electrophysiology following treatment (at 1 and 6 months).

CIED Planning Evaluation

Final TG-103 CIED Risk Level

- Patient CIED Dose Measurement
- Patient CIED Dose Risk Level

End CIED Eval

End CIED Eval

End CIED Eval

End CIED Eval

End CIED Eval

End CIED Eval
Live Demo
Customizable, Shareable Clinical Pathways with BPMN/DMN Now Possible in Radiation Oncology

Questions?

Contact

Raghavendiran Boopathy
Ph.D., DABR, Medical Physicist/Assistant Professor
www.ohsu.edu
boopathy@ohsu.edu

Gabe Colburn
M.S., DABR, Founder/CEO Quantek Systems
www.quanteksystems.com
gabe.colburn@quanteksystems.com