Managing Change in Radiotherapy
Automated treatment planning and
online adaptive radiotherapy

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Conflict of Interest Statement

- Consulting - Varian
- Grants - Varian, ViewRay, Siemens
- Licensing – Varian, ViewRay, Modus, MedLever
- Ownership – Radialogica, TreatSafely

“I did not have a 30 year long career in Radiation Oncology,
I had three 10 year long careers.”

Retired Radiation Oncologist
What is the vision (direction) for automated planning and online adaptive radiotherapy?

Hint: It is not automation, nor fast planning!
Is there an insight into the future from the short history of automated planning and online adaptive radiotherapy?

First, let's look at an old article

Some of Rock's thoughts

<table>
<thead>
<tr>
<th>Prediction</th>
<th>Today</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Radiotherapy has a future…&quot;</td>
<td>&quot;We are still here.&quot;</td>
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<tr>
<td>&quot;In a decade, CT-guided delivery will likewise become the rule, not the exception.&quot;</td>
<td>&quot;IGRT is ubiquitous.&quot;</td>
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<tr>
<td>&quot;Brachytherapy will also combine seamlessly with intensity-modulated radiotherapy (IMRT) and radiolabeled tumor-seeking agents.&quot;</td>
<td>&quot;SBRT is ubiquitous.&quot;</td>
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<td>&quot;And like surgery, radiotherapy will adapt during therapy to account for the patient's changing representation.&quot;</td>
<td>&quot;Online adaptation.&quot;</td>
</tr>
<tr>
<td>&quot;One foundation technology for adaptive radiotherapy is deformable registration to map one 3-D distribution to another. This will be an enabling technology in 4-D imaging to map all time points back to a common time for planning and analysis.&quot;</td>
<td>&quot;Deformation is ubiquitous.&quot;</td>
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Some of Rock’s thoughts

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<td>“In addition to chemotherapy for treating metastases, multiple courses of radiotherapy to widespread areas of the body—analogue to weeding a garden in addition to using herbicides—will be accomplished by avoiding critical normal tissue using image-guided radiotherapy.”</td>
<td>Multiple courses of RT commonly seen</td>
</tr>
<tr>
<td>“Due to 20 years from now, all potentially curative and many palliative patients will have image-guided SBRT.”</td>
<td>IGRT+MRT is standard of care</td>
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<td>As the speed of delivery and level of integration increases, the expert dose distributions and optimization of numerous beam angles will push SBRT toward intensity-modulated arc therapy paradigms.</td>
<td>VMAT</td>
</tr>
<tr>
<td>Protons, SBRT, automation of patient specific QA, automatic machine QA, etc.</td>
<td>Predictions for these individual technologies – all true</td>
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<td>“The clinical oncology medical physicist will have a role similar to that of clinical radiology colleagues—unwelcome news to most clinical radiation oncology physicists.”</td>
<td>Not true (yet)</td>
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<td>“Not revenue per medical physicist in a therapy department is about 40 times less than in a diagnostic imaging department. An automated patient specific QA procedures increase, pressure to reduce radiation oncology costs will be tremendous.”</td>
<td>Not true (yet)</td>
</tr>
<tr>
<td>“If our field’s technical revolution slows and the revenue falls consequent to the demise of the baby boomers, the number of practicing clinical radiation oncology physicians will drop. The next generation’s medical physicists must be skilled in computer science and medical imaging, which are the driving scientific forces supporting our field.”</td>
<td>True and specially important with the proposed Alternative Payment Model</td>
</tr>
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Is there an insight into the future from the short history of automated planning and online adaptive radiotherapy?

Let’s look at some slides from 10 years ago
Adaptive Radiotherapy - Quality


Vision - Reducing Variability

Back Then

- Could not have predicted the content of today’s presentation but understood the high level scope
- Knew that technologically it would be possible
- Knew clinical evidence would be needed for sustainability
- Knew that jobs and roles would change
- Knew that field would be slow to adopt change
Early evidence for online adaptive radiotherapy

Online Adaptive

• **Online**: Image, Re-contour, Re-optimize, QA, while patient on table
• **Adaptive**: For daily anatomic changes in target and organs at risk (OARs)

Systems Based Approach to Managing ART

[Image of a flowchart or diagram related to systems-based approach to managing adaptive radiotherapy]
Dose without adaptation

Benefits of adaptation
Clinical Application: Pancreas

Standard chemoradiation does not help locally advanced pancreas cancer

- “If cancer is the emperor of all maladies, then pancreatic cancer is the ruthless dictator of all cancers”
  - Deborah Schrag

Hammel et al., JAMA, 2016

Dose escalation may improve survival in LAPC

- Tumors >1 cm from a GI structure (25% of patients) were considered for hypofractionated dose escalation
- Patients who received radiotherapy with BED >70 Gy had an improved overall survival

Krishnan et al., IJROBP, 2016
What remains to be done?

Vision
My office will be in touch to schedule your simulation. Then we’ll schedule your treatments, which will start in 10 or 14 days. I already have a treatment plan ready. Do you want to start your treatments today or tomorrow?

Clinical Impact – Why?

- Clear evidence that wait time (diagnosis / surgery to start of RT) impacts control, survival, and quality of life
- 2 week delay: 6% (breast), 14% (post-op HN) relative risk of local recurrence, 3% (breast), 8% (HN) decrease in survival (Chen, Radiat Oncol 2008).
- Upstaging (1/3 of patients) from diagnosis to simulation, lung cancer (Everitt, Cancer 2010)
- Psychological stress of patients associated with increased wait times (Paul, Eur J Cancer Care 2012)
Vision

Remove RT simulation (imaging for treatment planning) entirely

Vision

- Diagnostic imaging is sufficient for radiation treatment planning.
  - For example, in some clinics, SRS uses diagnostic MR

- Adaptive radiation therapy allows ‘on table’ modification to daily anatomy
  - Onboard imaging is sufficient for treatment planning
  - Can adjust to pose changes, immobilization, etc.

How do we get there? Option 1

Plan on diagnostic images

Courtesy: T. Zhao
How do we get there? Option 1

- Use curved couches on treatment machines
  - Direct use of diagnostic images
  - More usable FOV
  - Better compatibility with arc delivery
  - Improved clearance
  - Less image artifacts
  - More stable
  - Improved patient comfort

How do we get there? Option 2

Online Simulation

Halcyon
iCBCT

How do we get there? Option 3
Conclusions

• “If our field’s technical revolution slows down ….”
• Our roles will change regardless:
  – Online adaptation
  – Continuous patient evaluation
  – Hypofractionation
  – Non-oncologic applications
  – Considerations for the proposed Alternative Payment Model and decoupling between some traditional physics roles and reimbursement
  – …
• “You either have to be part of the solution, or you’re going to be part of the problem.”
• Plenty opportunities to be part of the solution

Thank you!

• WashU faculty, staff, trainees
• Outside collaborators
• Alumni
• Industrial partners