Future of Radiation Therapy

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Cancer as a cause of death
CANCER TREATMENT MODALITY: RADIOTHERAPY

Localized Treatments:
- Surgery: less invasive?

Ablative Treatments:
- Cryo
- HIFU
- Laser
- Microwave

Systemic Treatments:
- Drugs: Traditional ChemoRx
- Hormonal Therapy
- Targeted Drugs

Very few curative therapies
Minor improvements in subsets of patients

Radiation Therapy (RT):
- Spectrum of biologic effects
  - Ablative: SRS/SBRT
  - Biologic therapy
    - Organ-sparing
    - DNA changes
    - Immune modulation
DISEASES TREATED WITH RT

Curable Cancers with RT ALONE:
- Prostate Ca
- Head & Neck Ca
- Lung Ca
- Cervical Ca
- Skin Ca

Curable Cancers with RT as part of treatment (adjuvant):
- Breast Ca
- Brain Tumors
- Testicular Ca
- Adv. Lung Ca
- Rectal Ca
- Sarcomas
- Adv. Cervical Ca
- Endometrial Ca
- Pediatric Ca
- Adv. Head & Neck Ca
- Bladder Ca

Metastatic disease: Bone / Brain / Other…
## Improving RT Delivery

<table>
<thead>
<tr>
<th>Period</th>
<th>Technology</th>
<th>Impact</th>
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<tbody>
<tr>
<td>1950-60s</td>
<td>Cobalt Early Linacs</td>
<td>Explore new indications</td>
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<tr>
<td>1970-80s</td>
<td>Higher Energy Linacs</td>
<td>Treat deeper tumors</td>
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<tr>
<td></td>
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<td>Decrease skin toxicity</td>
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<tr>
<td></td>
<td></td>
<td>Treat smaller areas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Individualization</td>
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<td></td>
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<td>Decrease toxicity in deeper organs</td>
</tr>
<tr>
<td>1990s</td>
<td>Beam Shaping Devices</td>
<td>Increase in tumor doses</td>
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<td>Improve tumor control</td>
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<tr>
<td>2000s</td>
<td>In-room Image Guidance</td>
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<tr>
<td>2010s</td>
<td>Integration of Better Beam Shaping and Aiming</td>
<td>Higher daily doses</td>
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<td>Faster, Better, Safer treatments</td>
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**Aim:** Increase Cure / Decrease Toxicity  
**Process:** Improve RT Shaping and Targeting
### Improving RT Techniques and Outcomes

<table>
<thead>
<tr>
<th>Novelty</th>
<th>Clinical Impact</th>
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</table>
| 1995-2000 | • Head/Neck: improve saliva / swallowing  
| Beam shaping devices: MLCs | • Pelvis: Less bowel toxicity  
| 2000-2005 | • Allows safer chemotherapy administration  
| In-room image guidance |  
| 2005-2010 | • Prostate Ca: Enable dose escalation: improve cure  
| Partially integrated systems | • Reduce traditional set-up errors  
| 2010-2015 | • Increased complexity  
| Hypofractionation, Adaptive RT | • Decrease throughput  
| 2015-Future | • Increase safety concerns.  
| Integration of Better Beam Shaping and Aiming | • Lung Ca SBRT: improve cure  
| | • Frameless CNS radiosurgery  
| | • Partial breast accelerated irradiation  
| | Need for increased integration and/or interoperability  
| | • Faster, better, safer treatments  
| | • Global RT:  
| | • Simpler set-ups  
| | • Education & training
Brain Mets Study: Adding SRS Improves Survival

RapidArc Radiosurgery: Treating 11 Melanoma Mets

Treatment Details
- 18 Gy x 1
- 4 non-coplanar arcs
- 1-360, 3-170
- 18 min treatment
- 5 min beam-on
- 708 control points
Lung Cancer:
Patients live longer with Radiosurgery than with Surgery

SBRT vs. Lobectomy for Operable Stage I NSCLC

PROSTATE CANCER
IMAGE GUIDANCE: IMPROVING CURE AND REDUCING TOXICITY

Cancer Control Rates

Toxicity Rates

Memorial Sloan Kettering Cancer Center
Prostate Cancer RT: Outcome with and without Image Guidance

Zelefsky, IJROBP, 84, 125-129, 2012
Shaping of Radiation Lowers Complications

Cancers impacted:
- Prostate Ca
- Rectal Ca
- Anal Ca
- Cervical Ca

Complications reduced:
- Less dryness of the mouth
- Less swallowing problems
- Less scarring of joints / muscles

Chopra et al. ASTRO Plenary, San Antonio October 2015.
Gupta et al. Radiotherapy and Oncology. 104:3 (343-348), 2012.
New Era Innovation

Knowledge-Guided Oncology | Intelligent Treatment Delivery
Advanced Data Analytics
RapidPlan™ Ramp Up

- 300+ Orders
- 3,800 Potential Installs
- Disease Site Models
  - Prostate
  - Prostate (+lymph nodes)
  - Head & Neck
  - Lung SBRT
  - Breast
  - More Models Coming

KNOWLEDGE-GUIDED ONCOLOGY:
Royal Surrey County Hospital: Prostate Study

<table>
<thead>
<tr>
<th></th>
<th>Manual</th>
<th>RapidPlan™</th>
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<tbody>
<tr>
<td>Time</td>
<td>114 ± 86 min</td>
<td>21 ± 13 min</td>
</tr>
<tr>
<td>Equivalent or better</td>
<td>30%</td>
<td>90%</td>
</tr>
<tr>
<td>Better</td>
<td>10%</td>
<td>90%</td>
</tr>
</tbody>
</table>

Planning time (min)

Courtesy, Royal Surrey County Hospital NHS Foundation, Guilford, UK
Data source on file
INTELLIGENT TREATMENT DELIVERY:

High Definition Radiotherapy (HDRT)
INTELLIGENT TREATMENT DELIVERY:

4π Dose Compression for Lung SBRT

PATIENT 1

PATIENT 2

IMRT

Work in Progress

INTELLIGENT TREATMENT DELIVERY:

High Definition Radiosurgery

Coplanar RapidArc SRS

4π High Definition SRS

Works in Progress
Concept only. Not available for sale.
Promise of Protons
InSightive™ Analytics

- Operational Efficiencies
- Referral Patterns
- Clinical Outcome Analysis
Velocity™

- Creates the cancer story from imaging
- Imaging informatics integrated with our Big Data Analytics
- Improve outcomes, quality, and efficiency
Radio-immunotherapy for Cancer Treatment

Hodge, Guha, Neefjes, Gulley. Oncology, 2008 August, 22(9):1064-1084
Abscopal Responses in Metastatic Non-Small Cell Lung Cancer (NSCLC) Patients Treated on a Phase 2 Study of Combined Radiation Therapy and Ipilimumab: Evidence for the In Situ Vaccination Hypothesis of Radiation


New York University

ASTRO Annual Meeting
October 2016
The Abscopal Effect:
Radiotherapy in one site can potentially eradicate tumors elsewhere in the body

- Combining radiosurgery with immunotherapy
- Study of NSCLC
- Study shows that SBRT with ipilimumab could increase tumor control and survival
- 25% remission; 100% control/no progression

Golden et al. ASTRO 2016.
Targeted Therapies and Immunotherapies: Trend is in Combining Drugs

Challenges of drug+drug combinations
- Clinical trial design
- Cost
- Commercialization

RT as a combination “drug”
- Available
- Cost-effective
- Reimbursed
4. Radiation Medicine

NEW FRONTIERS IN RADIATION ONCOLOGY

Research opportunities in radiation medicine:
- Cardiac arrhythmias
- Emphysema
- Post-thoracic surgery neuropathy
- Plantar fasciitis
- Depression
- Arthritis

Cardiac Arrhythmia
(Atrial Fibrillation)

Works in Progress
Cardiac Arrhythmias: A New RT Frontier?
Affordable, Accessible, Quality Care

Cost of Cancer Care in US
30% increase from 2010 to 2020

Average cost for one extra year of life:
1995: $54,100
2005: $139,100
2013: $207,000

Sources: Avalere study, 2015 National Bureau of Economic Research
Technology Decreasing Treatment Cost: SBRT / SRS
Utilizing time-driven activity based costing to understand the short- and long-term costs of treating localized, low-risk prostate cancer. Laviana et al. Cancer. 2015
Conclusion

• Advanced technology is increasing cure rates and lowering toxicity

• Advanced technology will improve affordability, accessibility, and quality of radiotherapy

• Radiation therapy utilization could dramatically increase with new opportunities outside of cancer
Thank You
INTELLIGENT TREATMENT DELIVERY:

Relative Clinical Value

The Key To Progress: Better Dose Delivery

- 3D CONFORMAL
- IMRT
- IGRT
- SBRT
- HDRT

$10M

$3-4M?