Overview of clinical implementation of IMRT

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disclosure

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references

“Guidance document on delivery, treatment planning, and clinical implementation of IMRT: Report of the IMRT subcommittee of the AAPM radiation therapy committee”
Ezzell, Galvin, Low, Palta, Rosen, Sharpe, Xia, Xiao, Xing, Yu
Medical Physics 30:2089-2115, 2003

“Implementing IMRT in clinical practice: A joint document of the American Society of Therapeutic Radiology and Oncology and the American Association of Physicists in Medicine”
Galvin, Ezzell, Eisbrauch, Yu, Butler, Xiao, Rosen, Rosenman, Sharpe, et al
Int J Rad Onc Biol Phys 58:1616-1634, 2004
what to think about

- treatment equipment
- treatment planning
- acceptance testing
- commissioning
- routine quality assurance
- dosimetry equipment
- monitor unit checks
- policies and procedures
- record-and-verify
- system integration
- patient immobilization
- charting
- space
- manpower
- training
- billing
A business can plan help

- Start-up costs (equipment, etc.)
- On-going costs (service/maintenance contracts, additional personnel, etc.)
- Overall increase in patient census
- Expected number of IMRT treatments
- Expected billing and revenue
- Timelines
lots of people are involved

physicist
physician
therapist
physicist
dosimetrist
engineer
administrator
what delivery method will you use?

- MLC
  - dynamic
  - step-and-shoot

- physical attenuators

- tomotherapy
  - serial
  - helical

- field-in-field
already have an MLC?

- **dynamic mode**
  - efficient delivery
  - relatively sensitive to MLC operation
  - no static segments to check

- **step-and-shoot mode**
  - less efficient delivery (may be very inefficient)
  - less sensitive to MLC operation
  - first segment can be used to visually verify treatment field
tomotherapy complete solutions

- serial
  - linac add-on
  - NOMOS
  - complete commercial solution

- helical
  - facility add-on
  - TomoTherapy, Inc.
  - complete commercial solution
field-in-field

- relatively simple technique
- forward planned
- need an MLC
- no patient-specific QA needed
- billable???
what about physical attenuators?

- known simple technology
- construction can be outsourced
- no MLC needed
- patient-specific QA is straightforward
- billable???
IMRT implementation at MDACC

business plan Mar 1998

- NOMOS MIMiC, Corvus, 6X Dec 1998
- Varian MLC(80), Corvus, 6X, prostate May 2000
- Varian MLC(80), Corvus, 6X, all patients Sep 2000
- Siemens MLC, Pinnacle3 Jan 2001
- Varian MLC(80), Corvus, 18X Jul 2001
- Varian MLC(120), Corvus Oct 2001
- Varian MLC(120), Pinnacle3, 6X Jan 2002
- Varian MLC(120), Pinnacle3, 18X Jan 2003
(in alphabetical order)

- John Antolak, Ph.D.
- Nathan Childress, M.S.
- Lei Dong, Ph.D.
- Ken Forster, Ph.D.
- Robin Kendall, M.S.
- Steve Kirsner, M.S.
- Rajat Kudchadker, Ph.D.
- Laura O’Neill, M.S.
- Karl Prado, Ph.D.
- Mohammad Salehpour, Ph.D.
MDACC IMRT utilization

Planning
Corvus
Pinnacle³

Delivery
Varian sMLC
NOMOS MIMiC
Siemens sMLC
treatment planning system

- System testing
- Beam modeling
  - Plan checks
  - Monitor unit verification
- Training
  - how to run the software
  - how to get a good clinical plan?
patient treatment planning

- more demanding than 3DCRT
- finer spacing on CT images
- multi-modality images and/or contrast
- more anatomy segmentation required
- more time to learn
- compare IMRT to 3DCRT and conventional
more conformal plans need better immobilization and localization
treatment delivery issues

- longer treatment times
- recovery from machine failures
- verification of correct beam
- verification of patient setup
- training
MIMiC setup verification
QA of patient treatments

- ion chamber for absolute output
- film for relative output
patient ion chamber QA results

Dec 1998 thru Jan 2004

Lei Dong, Ph.D.
patient ion chamber QA results

<table>
<thead>
<tr>
<th>Energy</th>
<th>n</th>
<th>average</th>
<th>sd</th>
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<tbody>
<tr>
<td>6MV</td>
<td>2488</td>
<td>-0.22%</td>
<td>1.9%</td>
</tr>
<tr>
<td>18MV</td>
<td>298</td>
<td>-0.22%</td>
<td>2.1%</td>
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<table>
<thead>
<tr>
<th>Service</th>
<th>n</th>
<th>average</th>
<th>sd</th>
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<tbody>
<tr>
<td>CNS</td>
<td>81</td>
<td>-0.23%</td>
<td>2.9%</td>
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<tr>
<td>GI</td>
<td>98</td>
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<td>2.1%</td>
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<tr>
<td>GU</td>
<td>1434</td>
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<td>1.7%</td>
</tr>
<tr>
<td>Gyn</td>
<td>105</td>
<td>-0.04%</td>
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<tr>
<td>Hem</td>
<td>33</td>
<td>-0.23%</td>
<td>2.0%</td>
</tr>
<tr>
<td>H&amp;N</td>
<td>832</td>
<td>-0.23%</td>
<td>2.0%</td>
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<tr>
<td>Pedi</td>
<td>26</td>
<td>-1.00%</td>
<td>2.9%</td>
</tr>
<tr>
<td>Sar</td>
<td>27</td>
<td>-0.94%</td>
<td>2.4%</td>
</tr>
<tr>
<td>Thor</td>
<td>142</td>
<td>-0.21%</td>
<td>2.7%</td>
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</tbody>
</table>
plan verification
fluence map verification
film QA at MDACC

- EDR2 film
- Vidar 16-bit scanner
- DoseLab in-house software
single-film calibration

Lei Dong, Ph.D.
Nathan Childress, M.S.
variation in film sensitivity
547 calibrations - 18 months

6 MV
240 MU

6 MV
360 MU

18 MV
240 MU

18 MV
360 MU

standard dev = 8-15%

standard dev = 7-8%
EDR2 time delay effect

Nathan Childress, M.S.
system integration

- transfer of images to planning system
- transfer of delivery parameters to linac
- transfer of information to RV system
shielding

- 2-4 times more MU for MLC based delivery
- up to 10 times more MU for serial tomotherapy

=> greater leakage
=> secondary barriers should be checked
=> for high energy beams, neutron shielding should be checked
John Antolak, Ph.D.
training

- physicists
- physicians
- dosimetrists
- engineers
- therapists
work effort and personnel

- Everything takes longer!
  (maybe it will get faster later)
- Who does what?
  outlining anatomy planning
  checking the plan and MU chart QA
  transferring delivery data plan dosimetry
- How many people will you need?
IMRT staffing - physics/dosimetry

- physics and dosimetry effort per patient (3/2000)
  - prostate  ~16 h/patient
  - others  ~22 h/patient

Assuming an average of ~20 h/patient,

\[ \Rightarrow \approx 100 \text{ patients/yr/FTE} \]
IMRT staffing - physics/dosimetry

March 2000 estimates

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<tr>
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<th>New patients per year</th>
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<tr>
<td></td>
<td>standard</td>
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<tr>
<td>1 FTE dosimetrist</td>
<td>200</td>
</tr>
<tr>
<td>1 FTE physicist</td>
<td>600</td>
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</table>

≈100 new patients/yr/FTE
making money - part 1

77301

“Intensity modulated radiotherapy plan, including dose-volume histograms for target and critical structure partial tolerance specifications”

--- CPT 2004

Mohammad Salehpour, Ph.D.
making money - part 1, continued

- 77301
  “(Dose plan is optimized using inverse or forward planning technique for modulating beam delivery (eg, binary, dynamic MLC) to create highly conformal dose distribution. Computer plan must be verified for positional accuracy based on dosimetric verification of the intensity map with verification of treatment set-up and interpretation of verification methodology)"

--- CPT 2004
making money - part 2

- 77418
  “Intensity modulated treatment delivery, single or multiple fields/arcs, via narrow spatially and temporally modulated beams (eg, binary, dynamic MLC), per treatment session”

--- CPT 2004