kV CBCT
Novel Clinical Applications and Future Directions
Douglas J. Moseley PhD, DABR

Department of Radiation Oncology
University of Toronto
Radiation Medicine Program
Princess Margaret Hospital

Objectives
• Standard Clinical Uses
  – Incident Reduction
  – Residual Error
  – OAR avoidance
• Novel Applications
  – On-line Palliative
• Summary

Image-Guided RT: Process

[Diagram showing the process of image-guided radiotherapy]

Overall kV Utilization 2008 (NC: 59, 8 images: 1446)

[Graph showing kV Utilization over time]

Commissioning
Process and Workflow

Automatic couch

New units, New Tx sites

2007 XVI Utilization (Px: 1946, Images: 32122)

2008 XVI Utilization 2008 (Px: 3532, Images: 36000)

Localization Incidents per Tx Course

JP Bissonnette, PMH

Start of 3D IGRT

Cut in half
IGRT Rx: The Prescription

- Imaging Technique
  - kVp, mA, ms
  - FOV, half vs. full scan
  - Imaging Dose

- Targeting
  - ROI (clip-box)
  - Manual vs. Automatic
  - Bone vs. Soft tissue

- Action Levels
  - Online vs. Offline
  - Shifts/Rotations

- Verification/Monitoring
  - Residual Error
  - Intra-Fraction Motion
  - Evidence-based margins

IMRT Lung

35 Gy in 20 fractions
V20 for both lungs <20%

Image guidance protocol
- Matched to bone
- Weekly cone beam
- Daily MV port films
- 3 mm action level shift couch
- Monitor soft tissue changes

kV CBCT Anatomical Sites

kV CBC T Anatomical Sites

IMRT Lung

35 G y in 20 fr ac tions
V20 for both lungs <20%

Image guidance protocol
- Matched to bone
- Weekly cone beam
- Daily MV port films
- 3 mm action level shift couch
- Monitor soft tissue changes
Soft Tissue Monitoring

Avoid Organs at Risk

Heart

High Dose Region (OAR) 30 in 3

ITV

PTV  60 Gy in 3
Avoid Organs at Risk

Planning CT

CBCT
- Target Localized
- Heart Inside
- High Dose Region

Avoid Organs at Risk

Patient
Re-Positioned

Planning CT

CBCT
- Target Localized
- Heart Inside
- High Dose Region

CBCT
- Target Re-Localized
- Heart Outside
- High Dose Region

CBCT information: T2N2c Postcricoid region

Problem: Significant tissue discrepancy between reference scan and CBCT at 3rd fraction
Reason: Tumour progression, acute swelling(?)
Result: RO notified, pt sent for emergency tracheotomy. Pt rescanned with new mask.

Residual Error – Various Anatomical Sites

Pelvis + fiducials

Thorax

Pelvis - Bone

Skull

- 4 sites (fiducials, thorax, pelvis, skull)
- 3 modalities (2D MV, 2D kV, 3D kV)
- 5 Random setups + IG
- Evaluate residual error (120 image sets!!!)

McNiven et al. 2008
Results: Residual Error

Prostate Residual Error

Prostate Fiducial Markers

MV kV CBCT

On-line Palliation

Population: 50% of all RT patients.
Bone metastases: 25% of all RT patients.

Palliative Intent: Quality of Life
Symptom Control (pain, neurological deficits, etc)

Effective Treatment: 8 Gy in 1 fx
Probability of pain relief: > 70%
Probability of re-treatment: 20%

(Chow et al. Meta-analysis, JCO 2007)
Summary of the Online Technique

- Same staffing as conventional technique
- Timing comparison

<table>
<thead>
<tr>
<th>Task</th>
<th>Online Technique</th>
<th>Conventional Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulation</td>
<td>37.4 ± 6.0 min</td>
<td>30 min</td>
</tr>
<tr>
<td>Planning</td>
<td></td>
<td>90 min</td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
<td>15 - 30 min</td>
</tr>
</tbody>
</table>

- First treatment: 30 min time slot
- Incentive for single fraction treatment

Summary

- CBCT widely available
- Low residual error
- Automated match and shift tools
- Paradigm shift
  - Soft-tissue OAR avoidance as well as target coverage
  - On-line planning and delivery
Acknowledgements

- PMH
  - Daniel Letourneau, Graham Wilson, Mike Sharpe, Tim Craig,
    Adam Bond, Mike Amer, Dave Lark, Terry McNaughton, Steve
    Ansell, Ben Norfinger, Jason Shaile, Noad Mal, Jean-Pierre
    Bisaouttel, Tom Parke, David Jeffrey
  - Laura Dawson, Cynthia Menard, Winnie Li, Sophie Fucroft
  - Andrea McNiven, Lee Coffin, Aaron vanDender, Xia Wu, Claire
    McCann

- Elekta/Impac
  - Kevin Brown, JS Stef, Andrew Long, Lindsay Watt, Tony
    Marlow, Leon Tomczyk

- Varian
  - Keith Siverson, Peter Munn, Bob Torka, Mika Miettinen, Corey
    Zarkowski