Clinical process of lung SBRT

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- SBRT process in steps
- Practical aspects
- CT, Treatment Planning, QA, On-line imaging, intrafraction motion, timings

Disclosure:
- VUmc has a research collaboration with Varian Medical Systems
- WV has received honoraria/travel expenses from Varian Medical Systems
4DCT scan

• Comfortable, reproducible patient positioning
  – Mattress, arms up or down
• Entire lung
• Reconstruction in 10 phase bins
  – Regular breathing?
  – At least at tumor position!
  – Beware of artifacts
If irregular breathing, make another short 4D
- If patient moved in between, make as new scan to avoid dicom registered images
- If resp. coaching is used at linac, use same coaching at CT
• Delineation by clinician
• Use MIP, extreme bins, all phase bins
• If 2 scans, review ITVs (summing, or not)
• Use margin for PTV
  – Depends on your setup accuracy
  – We use 5mm, 95% coverage of PTV [Rosel trial]

Location of Isocenter:
• Ensure beams can go around the patient (test at linac)
• Not too far off-axis
• In case of VMAT and off axis isoc: use partial arcs
• Take into account couch + mattress
  – Skin dose, extra attenuation

• All possible critical OARs (+ margin = PRV):
  Spinal cord,
  Lungs,
  Esophagus,
  Thoracic wall,
  Bronchus,
  Heart,
  Skin,
  Brachial plexus
  Stomach
• VUmc: 5 mm
  – RapidArc
  – Truebeam accuracy < 0.7 mm (system, match, couch)
  – Novalis Tx / Trilogy: < 1.5 mm
  – No margin for delineation uncertainty, no CTV (but ITV based)
  – Intrafraction motion patient: mostly < 1 mm.
• Others: typically 5 mm
• But if: all uncertainties considered for margin uncertainty
  – Margin for delineation error: 3-6mm!
  – NKI uses mid-ventilation GTV+8-9mm.
  – Note: mid-ventilation is phase with highest tumor speed
PTV margins lung SBRT

- Large calculated margins because of few fractions
- But: high fraction dose, large BED
- And no infinitive dose fall-off, ITV in cc-direction
- Small tumor: 3x18 Gy, steep fall-off, BED > 150 Gy
- Large tumor: 8x7.5 Gy, less steep fall-off, BED ≈ 105 Gy
- Local control (5y): > 90%
- Period 2003-2008: 3 mm margin, similar local control

⇒ SBRT lung is very forgiving for margins
- Difference between physicist and medical physicist
  - Be aware of possible toxicity
• Use standard protocols
• Good dose calculation algorithm (collapsed cone, AAA, Acuros, Monte Carlo)
  – Pencil beam: large deviations, especially for small tumors
  – Previously pencil beam: 3x20 Gy, now AAA: 3x18 Gy
• Technique:
  – 8-12 static beams
  – Conformal arcs
  – Cyberknife
  – IMRT
  – VMAT: 2 (partial) arcs. Optimal OAR sparing
Treatment planning

- For complex cases:
  - Multidisciplinary discussion: clinician, physicist, planner
- Prescribe maximum doses for OAR
- Use of a PRV? (spinal cord, esophagus, plexus)
- Other important OAR: contralateral lung, ipsilateral lung, thoracic wall, skin (stomach, etc)
- How to deal with
  - Multiple tumors?
  - Previous irradiation
  - Overlap PTV-OAR?
- Large tumors: sufficient lung sparing?
Plan verification by physicist

- 2 arcs
- ITV (no artifacts), margins, OAR
- DVH PTV(s), higher ITV dose
- DVH OAR (+margin)
- Optimization objectives
- MU per arc: within expected range? Not too many useless small leave openings?
- Avoidance sector / partial arc (not entering CL lung)
- Check movement of MLCs
- Finally plan QA
• Know your QA equipment
• Commission VMAT with high spatial resolution
  – Verify correct parameters as DLG, Leaf Transmission
  – Test for variety of plans: high modulation, low modulation
  – At VUmc, plan QA is done batchwise, coronal plane
    • Comparison is verified by medical physicist
  – Note that mostly, measurements are in homogeneous phantom. Patient treatment: in lung
• If commissioning shows TPS is correct, possible to use lower spatial resolution for standard QA
MatriXX IC array plan QA
Treatment

- Is the patient comfortable, and stable
- Can the gantry go around without collision (simple laser)
- Is the breathing constant, comparable during CBCT
CBCT based setup

- Regular breathing during CBCT?
- Match on PTV (+1 cm) in automatic match
- Manually adapt
  - No margin in automatic match if close to ribs
- Verify
  - Large tumor shift with respect to bones?
    - Extra attention to OAR doses
  - Tumor shape
    - Growth,
    - Different breathing
    - Atelactasis, effusion
    - Lung changes (density changes lead to dose changes)
st I lung SBRT (5x11Gy) setup: AvIP CT
CBCT for setup: small acceptable roll

- Check PTV, ITV, OAR, spinal cord tolerance, changes in lung
CBCT post RT (not standard anymore)
- Breathing during CBCT should be similar to breathing during RT: check with RPM
Real treatment time:
Analysis of 32 patients, 140 fractions
Lung SBRT using flattening filter free beams
- 10MV FFF, 2400 MU/min,
SBRT of lung cancer

Frameless high dose rate stereotactic lung radiotherapy: Intrafraction tumor position and delivery time

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- High accuracy CBCT before and after 2 arc RA
- 32 pts, 140 fractions, 10X FFF beams
- 3x18Gy, 5x11Gy, 8x7.5Gy
- Mean delivery time: 4.4 min
- Mean time CBCT- end last arc: 9.1 min
- Variations due to machine interruptions

**Treatment duration**

(a) Mean time to begin arc therapy was 4.7 min (2.0–14.1 min, SD = 2.1 min),
(b) Mean treatment time was 9.1 min (4.5–38.1 min, SD = 4.0 min),
(c) Mean beam-on time was 1.9 min (1.3–2.8 min, SD = 0.4 min),
(d) Mean time to deliver arc therapy was 4.4 min (1.8–33.3 min, SD = 3.4 min),
(e) Mean fraction time was 11.6 min (6.8–40.4 min, SD = 4.0 min).
Intrafraction motion lung SBRT

- 3D vector: 96% < 5mm
  80% < 3mm
- Similar to reports in literature
- No correlation with treatment time
- But: generally fast treatments
- W Li, IJROBP2010 (PMH): mean time between CBCT=25.5 min!

Peguret N, R&O 2013
- PTV overlapping with chest wall (PTVinOAR)
- Try to limit Dmax in PTVinOAR
- 2 arcs simultaneous optimization
- Final dose calc: too high dose
• Repeat last step of optimization
• Takes into account differences in dose calc between optimizer and AAA/Acuros
• Limits dose to PTV overlap

dose after 1st optimization

dose after cpo
• PTV consisting of $PTV_{OAR} + PTV_{lung}$
• \( \leq 140\% \) of dose accepted in $PTV_{lung}$ and ITV
• **Contralateral lung**: low V5
• Ring for dose fall off (**green line**)
• Ribs doses \( \geq V30 Gy \) minimized
Example: Reducing chest wall dose

- Plan for 8x7.5 Gy
- Thorax dose: V40Gy and V60-65Gy (inside PTV)
- Narrow optimization window for PTV in OAR
- Initial plan: V40Gy = 9%
Use of RapidArc in large tumors

High V5 is not necessary
SBRT for large tumors
(although not routine in many centers)

- 18 patients, av PTV 137 cc (87-286)
- 78% pulmonary and 72% cardiac comorbidity
- median follow-up 12.8 months
- N=5 pneumonitis grade 2-3
- Correlations with lung dose
  - TL and CL V5: p < 0.001
  - RP for TL V5 > 37% and CL V5 > 26%
- Use constraint for V5!
- Avoid contralateral lung

- Other study: n=69, 8 RP
  - Keep MLD < 3.6 Gy,

Ong CL, R&O 2010

Bongers EM, R&O 2013
Limit contralateral lung V5 (Ong C, R&O 2010)

- Use of partial arcs or avoidance sector
PTV vol > 200 cc: 2 partial arcs
When underdosing PTV

- In case of overlap with/ PTV near: esophagus, spinal cord, brachial plexus, stomach, colon
- Can also increase fractions

- Limit Dmax to 63-65Gy (8 fr) in
  - Heart, large vessels
  - Bronchus
  - Proximal bronchial tree
  - Chest wall

- But be aware for central tumors
Thank you for your attention

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