3 Dimensional Planning in Carcinoma Breast

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3D Planning: A Clinical Perspective

- Unique power to create and manipulate dose gradients
- Detailed quantitative treatment objectives

- Need to control and determine treatment margins through objective measurement of set-up uncertainties internal organ motion.
- All aspects of the radiotherapy process should be re-examined under more stringent requirements for accuracy and precision.
What is 3D Planning???

- It's complicated!
- A integrated system of technologies:
  - Patient setup and immobilization
  - CT-Sim, with complimentary imaging
  - Computer-aided treatment planning
  - Linac and MLC
  - Verification Imaging
- It is not a treatment modality or technique!
IMRT: A Technical Perspective

- IMRT is an extension of “3D Conformal” practices.
- Existing recommendations for RTP QA are applicable.
- IMRT technologies are integrated, i.e., “quality of IMRT/RTP plans depends on “up-and-down-stream” technologies.”
- Imaging, segmentation, R&V, accelerator, and PROCESS
The Evolution of IMRT

- The history of the arts and sciences could be written in terms of the continuing process by which new technologies create new environments for old technologies.

- You have to perceive the consequences of the new environment on the old environment before you know what the new environment is.

Marshall MacLuhan
3 DCRT Requirements

- Key technologies:
  - Imaging and Segmentation
  - Delivery
  - Optimization
  - Strongly interdependent
- Training.
- Systematic technical procedures and quality assurance.
When to use IMRT?

- Rapidly expanding applications:
  - GU, GI, GYN; Pelvic node irradiation, Dose escalation
  - Head & Neck: RTOG H0022, RTOG H0225
  - **Missing tissue and dose compensation (e.g. BREAST)**
- Preferably under protocol (e.g., RT OG)
- Previously treated patients

- Use caution:
  - moving targets (e.g., breathing, bladder filling, bowel gas)
  - tissue density variations (i.e., heterogeneities)
  - Simultaneous integrated boost (i.e., differential fractionation)
  - Achieve dose uniformity where possible
Breast 3 DCRT
Why do we need it?

- More conformal dose to breast
- Lower doses to lungs and heart
- Lower doses to contralateral breast
- Inclusion of regional nodes

3 D Planning: A Clinical Perspective
3D PLANNING PROCESS

- Setup & Immobilization
- Imaging
- Volume Segmentation
- Treatment Planning
- Evaluate & Verify Plan
- Treatment Delivery
- Verify Rx
Immobilization

- Minimize/control positioning uncertainties.
- Margins for uncontrolled uncertainty.
- Internal organ movement.
- Tissue deformation.
- Breathing, cardiac motion.
- Develop consistent "rituals" for use.
- Assess effectiveness, comfort.
- Reassess as treatment progresses.
- Be aware of weight loss, medications.
- Be aware of dosimetric impact, e.g., potential loss of skin sparing.
- Level of effort matches clinical goal and resources.
Initial Simulation

- Immobilization: alpha-craddle
- Position arms above head, keeping elbows tucked in
- Treatment side of the cradle is compressed to avoid interference with the lateral tangent setup and SSD readings
Initial Simulation

- Position the patient level and straighten under fluoroscopy
- Level marks (tattoos) are made on each side of the patient at about 5 cm below xiphoid with the lateral lasers
- Tattoos at ~10 cm off the tabletop
CT Scan

- Position patient level and straighten on the table using the midline, level marks, and the marks on the cradle
- Place a "b.b." on midline, if the medial wire placed by physician is not located on the midline
CT Scan

- Patient should be in the center of the table, unless the affected breast is too large
- If the treatment site is not in the field of view, move the patient off-center to assure a complete scan of the affected breast
CT Scan

- Acquire a scout view of the entire chest, start superiorly from the chin and end inferiorly below the leveling marks.
- Image set should include above and below the 1st and 12th thoracic rib respectively.
- Set center of the field (zero slice) in middle of the breast, between catheters placed by physician.
- Scan the central axis slice; check for straightness and rotation.
Marker Placement for Reference to Isocenter
Virtual Simulation

- Virtual CT simulation in the standard treatment position
- Treating physician places radio-opaque markers at the clinical borders of the ipsilateral breast tissue
Virtual Simulation

- During treatment planning: the superior, inferior, and deep edges of the unopposed tangential beams are aligned with the radio-opaque markers.
Treatment Planning

- Contour
- Beam alignment
- Beam weight
Key to Successful Treatment

OPTIMAL TARGET DELINEATION
General Tissue Segmentation

- Explicitly delineate targets requiring dose, and every organ at risk (objectives, and evaluation).
- Generally more volumes than 3D planning.
- Margins:
  - Adequate evidence for designing PTV?
  - Consider margins around critical structures to partially account for organ motion, patient movement and setup uncertainties (cord + 0.5 cm)
- Avoid volumes extending outside the patient.
- If target includes buildup region, consider bolus.
Target Volumes

ICRU 50 & 62
GTV - Gross Tumour Volume
CTV - Clinical Target Volume
PTV - Planning Target Volume

Accounts for internal organ motion and patient setup variations.
Margins should also be applied to organ at risk (OAR's -> PRV's).
The PTV must be large enough to ensure the CTV receives the prescribed dose.
The larger the PTV, the more normal tissue is irradiated.
Need to reconcile PTV/PRV overlap.
Tangent Beam Alignment

- Align tangential beams to coincide with radio-opaque markers

- 1.5 cm - 2 cm depth into lung
SKIN, LUNG, and BREAST

- Contour skin and lung
- Create breast contour through contraction tool
CONTOURS - Skin & Lung

- Auto contour skin and lung
- Lung
  - lower threshold 150
  - upper threshold 800
CONTOURS - Beam Edge

- Contour the tangential beam edge to create a "Dummy ROI"
CONTOURS - Beam Edge

- Contour the tangential beam edge to create a "Dummy ROI"
CONTOURS - PTV_eval

- Create PTV_EVAL by contracting BREAST ROI by 5mm
Beam Weight

- Open field plan is created
- Heterogeneity correction is utilized
- Beams are weighted to a normalization point 1 cm anterior to the chestwall
Beam Selection

- Often, equally-spaced, unopposed, coplanar beams
- Use geometry to advantage; ie, angle beams to:
  - miss critical structures,
  - treatment table (couch bars)
  - immobilization devices
- Minimize number of beams, to reduce planning, setup, and delivery time.
- Higher energies reduce peripheral dose and less impact when more beams.
- Depends on the complexity of the target shape and its proximity to critical structures.

Dose Segment - ROI
Beam Segments - Open Field
BEV: Block to Lung
MLC Segments

- Calculate an isodose distribution for a pair of open tangential fields (no blocks or wedges).
- Subdivide medial and lateral beams into MLC segments; conform to isodose lines, i.e., increments, i.e., 120%, 115%, 110%, 105%...
BEV: Dose ROI
BEV: Block to Dose ROI
MLC Segments

- Open Field
- Lung Block
- Multiple Segments
3 DCRT: Optimization
PLAN EVALUATION

- Dose uniformity is achieved throughout the treatment volume
- <15% of breast volume receives >105% of the prescribed dose
- <2% of breast volume receives >110% of the prescribed dose
Final plan evaluation

- Review the DVHs, all structures.
- Review ROI statistics (min, mean, max dose)
- Adjust your prescription isodose, if necessary.
- Review the isodose distribution:
  - in multiple planes;
  - 3D dose clouds.
  - Un-segmented tissues.
- Check the maximum dose for the plan.
- Several different dose distributions may satisfy the same set of dose-based objectives
- Run several competing plans scenarios if needed.
Technical Procedures & QA

Key to success: Clear (Documented), Concise, Meaningful, Maintainable

Review and Revise

Avoid Moving Targets!
Quality Assurance

- Hand calculation at isocenter
- Central axis diode measurement
- Daily electronic portal verification
- Segment review
- MapCheck measurements
EPID (Electronic Portal Imaging Device)

2nd Generation Electronic Imaging Amorphous silicon panel
KV Imaging on the Treatment Machine

Amorphous silicon panel

Retractable Kilovoltage X-ray tube
Treatment Delivery

- Treatment time (~10 minutes) is not increased compared to conventional techniques.
- Electronic portal images of medial and lateral daily.
- Image acquired during first few monitor units of open segment.
Treatment Delivery
Ca Breast
3D planning of two tangential beams
Ca Breast - Isodose
Fig. 12. (Color) Lateral and medical tangent digitally reconstructed radiographs for setup verification of the lateral and medial tangent treatment field. The heel of the wedge is towards the $X_1$ (left) yaw as indicated in the DRR of the lateral tangent field on the right.
DVH
Dose Volume Histogram (DVH)
Plenary 1

Phase III Randomized Study of Intensity Modulated Radiation Therapy Versus Standard Wedging Technique for Adjuvant Breast Radiotherapy

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3 DCRT SUMMARY

- 3 DCRT technical evolution, not a treatment modality *per se*.
- Consider all aspects of the radiotherapy process.
- Commission planning system, “learn how to drive”, and validate each treatment planning procedure.
- It is difficult to “decouple” all components of planning software.
- The dependence on images and segmentation requires adherence to clinical protocols.
IMRT and intensity modulated treatment planning