IMRT/IGRT Treatment Plan Safety Measures

Ping Xia, Ph.D.
Don DiGeronimo and Betty Raghavan
Endowed Chair in Medical Physics
Cleveland Clinic
What Can Go Wrong?

• With recent series articles in NY Times, radiation oncologists are getting uneasy about safety of treatment plans and delivery.
• Fast paced advancement in technology of radiation therapy makes radiotherapy process much more complicated nowadays.
• How to delivery modern radiotherapy safely and efficiently?
• How to avoid gross errors?
Adaptive to Changes from Conventional Delivery to Modern Delivery

- From manual data entry and recording to electronic data transferring and recording.
- From everything on paper to everything electronically.
- From intuitive beam shapes to non-intuitive beam shapes.
- From a few beams to many beams.
Standardize Procedures

- Understand the entire planning and delivery process and get every team member involved to prevent gross errors.
- Carefully document things may cause potential mis-understanding among different teams.
- Establish standard communication languages, procedures, and protocols.
Identify Potential Errors in Simulation, Planning, and Delivery
Starting From CT-Simulation

• With CT-simulation, the coordinates of the isocenter is directly sent to a treatment planning system.
• Isocenter is marked on patient body after CT acquisition, therefore, there is no markers on any CT image to show location of the initial isocenter.
• Is iso-center correctly marked on patient body, matched with the coordinates sent to treatment planning.
• What is the procedure to check this information.
Importance of Iso-center Check

Planning CT

Second Single slice CT

Slice 36: Z = 110.300
Isocenter

Position patient such that lasers line up with patient marks.
No left/right table adjustment is required.
No up/down table adjustment is required.
No in/out table adjustment is required.

Slice 36: Z = 110.300

#36, -1,103.0 mm
100.0 cm
90.2/88.2 cm
81.0/81.8 cm

Nearest Z Slice
SAD
AP/PA SSD
RT/LT SSD

From treatment plan
From simulation note
Are they matched?
Treatment Planning

• Chose a wrong planning CT, especially for adaptive planning with multiple planning CTs.
• Did not set the initial iso-center at the location as marked on the patient body.
• Did not set the dose matrix size to cover all region of interest, resulting incorrect dose volume histograms.
Inadequate Dose Grid

Too Small Dose Grid
Treatment Planning

- Isocenter shifts are not properly documented, or communicated with the delivery team.
- DRRs generated from the planning system are not properly scaled.
- Iso-center of DRRs is not the planned iso-center.
- Some planning systems will automatically set the latest calculation point as the default iso-center of new beams.
Treatment Planning

- The approved plans did not use correct dose calculation method
  - To improve speed of IMRT optimization, treatment planning systems often utilize a simpler, fast, yet less accurate dose calculation method during optimization.
  - The final plan needs to be calculated with a more accurate dose calculation method.
Treatment Planning

- The approved plans did not calculate with proper dose grid size
  - To improve speed of IMRT optimization, planner may use smaller dose grid size
  - The final plan needs to be re-calculated with a larger dose grid size to cover all region of interests.
Treatment Planning

• The approved plans were not deliverable
  – Some treatment planning systems use two step optimization method
    • Step 1 obtains an ideal IMRT plan with continuous intensity profiles
    • Step 2 converts all IMRT beams into MLC deliverable shapes.
  – It is possible that the IMRT plan you reviewed or approved was an ideal plan, not a deliverable plan.
Possible Errors in IGRT
Added New IGRT QA

• Daily IGRT QA
  – Assure alignment between laser, table, and imagers.

• Monthly QA
  – Assure accuracy of table movement.
  – Check alignments all imager systems, such as KV-CBCT, ultrasound system, calypso system, optical system.

• Check and understand accuracy of each imaging registration systems.
Iso-Center Again For IGRT

Iso-center location in Mosaiq

Iso-center location in Planning system
Index Patient Positioning

• Patient’s position on the treatment couch can be indexed with 0.5 cm to 2.0 cm accuracy, depending on the treatment site.
• This controls where each patient should be positioned on the treatment couch.
• Indexing patient position on the treatment couch can prevent wrong treatment site or wrong patient being treated.
• Established site specific index positioning tolerance tables.
Implementing Time out

• Before beam on, a time out should be implemented by loudly saying the patient name, treatment site, and then electronically signing off.
Cross Check Isocenter – Check SSD

- Check SSD again if treatment couch is manually moved, such as in the use of non-planar beams.
- Check SSD for each beams of a new plan.
Standardized Procedures and Checklists
SOPs and Checklists

• Establish written standard of procedures (SOPs).
• Periodically visiting these SOPs and modifying them if necessary.
• Using Checklists to enforce SOPs and reduce deviations.
• Any procedure deviation is recorded by therapists.
• Regular weekly meeting to discuss procedure improvement, reducing frequency of procedure deviations.
Standard Field Names and Notations

• Standardized field names, including field names for modified fields.
• Gantry angles and table angles are spelled out in the field names, and must be matched with the actual angles.
• Bolus thickness are spelled out in field names.
• Isocenter shifts must be documented in two places – in the plan and in the specific treatment instruction.
Physics Checklist

- Rx matches plan (energy, dose, IDL and # fractions) and plan is valid for Tx
- Rx and Plan approved by physician
- DRRs/Sim films approved
- Planned isocenter matches simulated isocenter, otherwise shifts are documented in Plan
- Treatment plan uses intended treatment unit for all beams
- If CBCT, view reference CT from Site setup to verify the correct isocenter is used
- Calc/Plan is signed by the planner and co-signed by physics
- Radcalc and plan agree within 5%, 3 MU, or 3 cGy. Otherwise a note should be documented (for non-IMRT plan only)
- Radcalc is signed (for non-IMRT plans only)
- If IMRT, an IMRT QA procedure is listed on the patients QCL stating QA is ready
- Diode sheet has ranges filled in for the fields to be measured
- Field naming correct
- Check Table vertical is the same for all fields under the same Rx
- Correct tolerance table is selected in mosaiq
- Individual field doses in mosaiq sum to total Rx dose
- Check all field parameters and approve all Tx fields in mosaiq
- Check that a Tx calendar exist with correct number of fractions
- Add a procedure item to the treatment unit’s QCL
A. Pinnacle
- Send plan to RadCalc
- Send plan to Mosaiq
- Send DRRs to Mosaiq
- Send plan and Images to iVIEW or Mosaiq (CBCT – indicate time sent)
- Send related image files to Mosaiq
dvh
idls
bevs
diagrams (if needed)

B. Mosaiq
- Import FTP plan
- Prescription is complete and approved
- Treatment fields completed
- Dosimetry completed
- Treatment calendar created
- Insert table vertical for each field
- Associate correct tolerance tables to the plan
- DRR’s
  - associated
  - scaled
  - approved

C. Notes:
- appropriate SSDs
- required notes, i.e. shifts needed per plan, CBCT, etc.
- note locked

D. Documents:
- TP Plan signed/co-signer has correct name
- Diode sheet completed/review request
- SSD sheet completed
- CBCT form completed and signed if needed
- Fusion note if needed
- Billing complete
- Place on physicist quality checklist

Checklist for Dosimetrists
External Audits
Utilize National Service Systems

- Radiological Physic Center at MD Anderson is sponsored by NCI.
- The main mission of the center is to assure dose accuracy of all clinical trials.
- There is an incentive to become RTOG member and enroll patients for clinical trials.
- RPC will independently check irradiated TLDs for machine calibration, especially for newly installed machines.
- Irradiate site specific phantoms from RPC to check IMRT plan delivery accuracy.
RPC Available Phantoms

SRS Head Phantom

IMRT Head and Neck Phantom

http://rpc.mdanderson.org/rpc/
RPC Available Phantoms

Liver Phantom

Prostate Phantom
RPC Available Phantoms

Spine Phantom

Lung Phantom
Summary

• Radiation is an irreversible process.
• With increasing use of hypofractionation radiation, such as in SBRT, QA process becomes extremely important.
• Standard communication languages, written standard of procedures (SOPs), check list, time out, are a few example to ensure safe delivery of radiation.