Planning And Delivering HDR Accelerated Partial Breast Irradiation TREATMENTS

Acceptance Testing For HDR Planning, Remote Afterloader And APBI Applicators

Angelina Bacala, PhD

OUTLINE
- Short description of the high dose rate (HDR) brachytherapy for Accelerated Partial Breast Irradiation (APBI)
- Introduction to Oncentra planning system and acceptance procedures for a new source
- The applicators: Savi, Contours, ML Mammosite and acceptance testing
- A preview of the remote afterloader
HDR BRACHYTHERAPY FOR APBI

APBI
- An approach that treats only the lumpectomy bed plus a 1-2 cm margin\(^1\)
- A decreased dose to normal tissue
- Tumor size < 3 cm\(^1\)
- Patient selection criteria, table 1\(^2\)

Table 1\(^2\)
American Brachytherapy Society (ABS) acceptable criteria for partial breast irradiation

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Acceptable Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>≥ 50 years old</td>
</tr>
<tr>
<td>Size</td>
<td>≤ 3 cm</td>
</tr>
<tr>
<td>Histology</td>
<td>All invasive subtypes and DCIS</td>
</tr>
<tr>
<td>Estrogen receptor</td>
<td>Positive/negative</td>
</tr>
<tr>
<td>Surgical margins</td>
<td>Negative</td>
</tr>
<tr>
<td>Lymphovascular space invasion</td>
<td>Not present</td>
</tr>
<tr>
<td>Nodal status</td>
<td>Negative</td>
</tr>
</tbody>
</table>

Fraction, target volumes, and acceptance criteria
- Fractionation: the most common 34 Gy in 10 fractions twice a day (BID) for interstitial and intracavity\(^3\)
- Dose limitations for normal tissues: uninvolved normal breast, ideally <60% of the whole breast reference volume should receive ≥ 50% of the prescribed dose\(^3\)
- PTV-eval is the breast tissue volume bounded by the uniform expansion of the balloon/cavity radius in all dimensions less the balloon/cavity volume
- Dose volume histogram (DVH) analysis of target coverage will confirm ≥90% of prescribed dose covering ≥90% of the PTV-eval
Fractionation, target volumes, and acceptance criteria

- (%PTV- eval coverage) - [(vol trapped air/vol PTV-eval) x 100] ≥ 90%
- At least 95% of the PTV-eval receiving 90% of the prescribed dose
- The volume of air/fluid trapped in PTV-eval < 10%
- V150 ≤ 50 cc
- V200 ≤ 20 cc
- Skin ≤ 100% of the prescribed dose

ONCENTRA PLANNING SYSTEM AND ACCEPTANCE PROCEDURES

Import
- Location of DICOM import files received by OTP Dicomserver: C:/OTP_DATA/DICOM/Incoming

Automatically filled in with ID, Last Name. Case Label must be entered.
Brachy planning activity:

- Source definition: select a Nucletron remote afterloading system with a specific calibrated radioactive source for HDR brachytherapy
- Catheter reconstruction: reconstruct the catheters using the acquired images (manually or automatically)
- Activation of source dwell positions: define which source dwell positions in the catheters are activated for treatment (manually or automatically)
- Defining points: for reporting and normalization on patient, applicator or dose points

Dose normalization: set the reference isodose line with a selected normalization method
- Dose optimization: optimize the homogeneity and shape of the target dose distribution while sparing normal tissue
- Dose prescription: assign an absolute dose (cGy) to a relative dose (%), typically 100%
- Plan evaluation: calculate and evaluate DVHs, review planar isodose distributions, review 3D reconstructed doses
- Plan reporting: treatment printout
- Plan exporting: the treatment plan can be exported to another treatment planning system or to afterloader
Preparing the system

- Defining the afterloader and source: Before making a treatment plan, the Radiation Data Storage (RDStore) tool is used to define the treatment machine (afterloader and source).

- Global system settings for brachy:

New plan

- Can be created opening the BP activity.
- Or using the Search View.

New plan

- Clicking “select plan” in the portal menu (or F7).
- You can also copy a plan.
Verifying import and export of images
- Attend the scanning process, evaluate the images and the patient’s positioning
- Import the images and compare with the CT scanner’s images and the measurements the therapist took at the scanning time

Dose calculation
- The best is using a secondary dose calculation by: developing your own dose calculation spreadsheet or using a 3rd party software like MUcheck, Radcalc, and others

Entering the source in RadCalc
- Go in utilities and chose Physics Setup
- Select Brachytherapy sources
  - In Source Parameters you can add, remove, and edit source parameters

- In Source Inventory you can add, remove, and enter the source strength and the date of calibration
APPLICATORS USED FOR THE APBI TREATMENTS

- Multi Lumen Mammosite (MLM)
  - Balloon filled with water and contrast
  - 4 catheters, one central and 3 around

- Contura
  - Balloon filled with water and contrast
  - 5 catheters, one central and 4 around

- Savi
  - Wisk like wires
  - Multiple sizes
Before use verifications
- Diameter when balloon filled or Savi expanded
- Treating length
- Measure distance to first dwell position

Before use verifications
- Locate the first dwell position

Before use verifications
- Measure the delivered dose
Thank you!

Planning for APBI using Savi, Contura and ML Mammosite applicators

Silvia Pella, PhD, DABR

OUTLINE

- Short description of the high dose rate (HDR) brachytherapy dose calculation
- Importing CT scans
- Catheters reconstruction
- Enter prescription
- Planning
- Evaluating the plan
- Exporting the plan
Goal: achieve a dose distribution that will treat the PTV without exceeding normal tissue tolerances

Parameters needed:
- Source type
- Source length
- Number of source positions
- Spacing
- Dwell times in each position

HDR BRACHYTHERAPY DOSE CALCULATION

- Dose calculation
  - TG 43 algorithm
  - Two-dimensional (2D) dose-rate equation
  \[ D(r, \theta) = S_k \cdot \Gamma \cdot G(r, \theta) \cdot g(r) \cdot F(r, \theta) \]
  - \( S_k \) = air kerma strength (1U = 1μGy m² h⁻¹)
  - \( \Gamma \) = dose rate constant (cGy h⁻¹ U⁻¹)
  - \( G(r, \theta) \) = geometry factor
  - \( g(r) \) = radial dose function
  - \( F(r, \theta) \) = anisotropy function

IMPORTING THE IMAGES

- Using the method described in the previous presentation we import the patient’s scans
**IMPORTING THE IMAGES**

- Enlarge the upper corner image and choose Point selection tab to make the images perpendicular to contour the Cavity/balloon - CTV.

**Structures segmentation**

- Generate the External structure using the automatic contouring feature.

**Structures segmentation**

- Skin:
  - Shrink the External structure with 2 mm and generate a new structure – help
  - Extend the cavity with 40-50 mm electing to avoid the External and help structures this will give you the skin structure.
Structures segmentation

- Air: use the Magic Wand feature to fill the air space
  - Then subtract the cavity’s volume from the air without creating a new structure

- Ribs: using Magic wand and choosing the proper contrast
- Chest wall: contour the chest wall in all the slices that will contain the PTV
- PTV: expand the CTV with 10 mm avoiding the skin surface and the chest wall and keeping a distance of 1 mm between the PTV’s wall and the two other structures

Catheters reconstruction

- Being in the ECS view identify the catheter positions and numbers and enter a point for easy recognition for each of them
Catheters reconstruction

- Once reconstructed verify them and enter the lengths and the offset.

Entering the prescription

- Check that you have the physician’s prescription and enter the prescription. Check for the correct source.

Optimization

- Using IPSA you can optimize automatically.
Optimization

- Or you can perform a manual optimization

- Or you can use the normalization function using points placed on the PTV

Evaluating the plan

- Dose volume histogram (DVH)
  - Generate and use to analyze the quality of the plan
Evaluating the plan

- Use the B39 criteria

<table>
<thead>
<tr>
<th>Volume (cc)</th>
<th>Distance (mm)</th>
<th>Parameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV40</td>
<td>76.45</td>
<td>Skin (mm)</td>
</tr>
<tr>
<td>Canine</td>
<td>52.33</td>
<td>Ribs (mm)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Air</th>
<th>O2</th>
<th>N2</th>
<th>Goal</th>
<th>Accept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max % Dose</td>
<td>0.1</td>
<td>80.56</td>
<td>% 50%</td>
<td>± 25%</td>
</tr>
<tr>
<td>PTV40</td>
<td>77.21</td>
<td>93.45</td>
<td>± 10%</td>
<td>90%</td>
</tr>
<tr>
<td>PTV60</td>
<td>74.88</td>
<td>90.12</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>PTV80</td>
<td>72.77</td>
<td>90.12</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>PTV90</td>
<td>12.85</td>
<td>--</td>
<td>± 5%</td>
<td>± 20%</td>
</tr>
</tbody>
</table>

The contour reported reflects the arc coverage submitted in your case.

Exporting the plan

- Once the physician approved the plan and a second physicist verified it, approve the plan and export to TCS

- Export to Radcalc for a second hand verification

- Export only the plan
Printing the documents

- Print
- The treatment plan
- DVH
- Isodose distribution in 2D and 3D
- The Radcalc verifications
- Merge all the documents and upload them in the patient’s chart

Thank you!

Treatment delivery and quality management procedures (QMP)

Madhu Chilukuri, PhD, DABR
OUTLINE

- Short description of the high dose rate (HDR) brachytherapy QA
- The morning QA
- Import the plan
- Verify the new scan
- Connect the patient and deliver treatment
- End of treatment
- Exporting the plan

First QA

- Patient at the first scan (the one used for planning)
  - Mark the skin in line with the catheter on top of the exterior tube
  - Measure the distance between the skin and the key inserted around the tube to keep the Savi in a fix position
  - Document the setup for reproducibility
**First QA**

- Patient at the first scan (the one used for planning)
  - On the scout image measure the diameter of the cavity/balloon
  - On the images taken identify the nearest distance to the skin and ribs, measure them and document the measurements.

**The morning of treatment QA**

- Before treatment delivery
  - Interlocks
  - Check the emergency kit

- Check source’s first dwell position
  - Films
  - GafChromic
  - Video camera
The morning of treatment QA

• Survey the remote afterloader and the room

• Check the in-room radiation monitor

Quality management program

1. Written directive
2. Patient Identification
3. Treatment Plan Verification
4. Pre-treatment safety checks
5. Treatment delivery
6. Post-treatment safety checks
7. Source replacement and Calibration
8. Documentation
9. Supervision
10. Medical events
11. Periodic review

QMP report

• A good report should document the following
1. Written directive
2. Source and source strength
3. Technique
4. Step size, dose delivered, total # of dwell positions
5. Individual and total dwell times
6. Reference position
7. Isodose distributions, DVH statistics
   Independent validation of dose and calculations
   Pre and post treatment radiation survey
**When do we perform QA?**

- Every source change
- Every day of treating
- Monthly
- Annual

**Policy and procedures**

- Well assigned roles
- Clear instructions for each team member
- Follow protocols
- Physician present at all times

**Transfer tubes acceptance**

- Different lengths
- Visual inspection for mechanical integrity
- Store to keep integrity
- Measure length as received
- Test connection
- Test transfer of source

**Import the plan**

- Import the plan and verify the printed from the treatment console dwell times and positions with the imported ones
- Verify the connectors and the dwell positions
- Verify the correct activity
Verify the new scan of the 1st fraction and the subsequent ones

- Verify the new scan with the initial one for each fraction.
- For the first treatment import the scan in the TPS and fuse it with the planning CT.
- Evaluate the change and the eventual need for re-planning. Plan went from 98% coverage to 86%.

Connect the patient and deliver the treatment

- Survey the patient before and after the treatment.
- Check transfer tubes before engaging in treatment delivery.

End of treatment

- Survey the patient and the remote afterloader.
- Disconnect the transfer tubes.
- Document the treatment in the patient’s chart.

Emergency procedures and manual

- Establish emergency procedures.
  - USNRC and TG-59 recommends.
  - Users shall learn and periodically retrain to operate the devices and to respond properly to emergencies.
  - Written emergency procedures describing actions to be taken, including surgical intervention, should the source not return to the shielded container at the conclusion of treatment.
  - Appropriate staff and equipment available in support of these procedures.
Emergency procedures and manual

- Emergency instructions and manuals
  - Operator’s manual
    - Function of the console
    - How to program a treatment
    - Check the time factor
  - Emergencies procedures
  - List of authorized users (posted)
  - List of names with phone # for emergencies (posted)
  - List of error messages

Major emergencies

- Source retraction failure
- Patient medical emergency
- Total computer failure, etc.
- Involve operator, radiation oncologist, the physicist.

Minor emergencies

- Loose source guide tube connector
- Vault door not properly closed
- Kink in the tube
- Ring not locked, etc.
- Easy recovery actions that allowing treatment to resume
Main goal for emergency procedures

- Reduce the radiation dose to the patient by retracting the source from the patient as soon as possible
- Minimize the radiation exposure to personnel performing the source retraction

Why errors?

- Individual mistakes, lapses in judgment, or device malfunctions
- Transient malfunction of a device (afterloader, applicator, or planning system)
- Failure of a team member to follow established policies
- Making a mistake while following policies
- Relying on policies and procedures which are inadequate

Why errors?

- Failure to follow procedures may be caused by:
  - Inadequate training, inadequate supervision, or excessive time pressure.
  - Making mistakes while following policies is often a consequence of
    - Inadequate documentation or training
    - Poor intra team communication
**Why errors?**

- Poorly designed treatment-planning and remote-afterloader interfaces,
- An inexperienced or incompetent team member
- Suboptimal working conditions, or
- Excessive time pressure.

---

**Routine emergency equipment**

- At the console outside the room:
  - Sign "Danger-Open Radiation Source-Keep Out!"
  - Geiger–Muller meter ~0.1–100 mR/h range!
  - Ionization survey meter ~1–1000 mR/h range!
- Inside the room:
  - Emergency Container
  - Forceps
  - Kelly surgical clamps
  - High quality flashlight and fresh spare batteries
  - Suture removal kit
  - Suture kit

---

**Routine emergency equipment**

- Emergency container
  - Mobile
  - Large and deep enough
References

3. NSABP B-39
4. Oncentra user manual

Hope your HDRs are uneventful and of a very high quality
Thank you
??? Questions ???