Clinical implementation of Electronic Brachytherapy (eBT)

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Disclosures

- Speaker for ELEKTA
Current eBT systems

- Intrabeam® by Zeiss Surgical
- Xoft® by Icad Inc.
- Esteya® by Elekta
- SRT-100™ by Sensus Healthcare
- Photoelectric Therapy by Xstrahl Ltd
- Papillon (UK only) by Ariane Medical Systems Ltd

Good reference:
Implementation of eBT program
Items to consider for the eBT program

- Room
- Staff/coverage
- Equipment
- Regulatory items
- Acceptance testing
- Commissioning
- Policy and procedures
- QM program
- Staff training
- End to end case (With all staff involved)
Room selection

- Accelerator room (1)
- Sim room (2)
- Exam room (3)
- others
Staffing

- Similar to HDR Brachytherapy staffing
- Dermatologists are purchasing these to be used in their offices (Potential issues with staffing, Q.A., patient safety)
Delivery system and accessories
Equipment to perform commissioning
Door interlock system, A/V, intercom
Emergency buttons installed in the room and outside
Portable shield (if needed)
Regulatory: check your state regs.

64E-5 Florida Administrative Code 64E-5.1601

Rules 64E-5.1601 — 64E 5.1604 are effective March 12, 2009 and are designated as Revision 9 (R9).

PART XVI
ELECTRONIC BRACHYTHERAPY

24.13 Electronic Brachytherapy.
AAPM REPORT NO. 152

The 2007 AAPM response to the CRCPD request for recommendations for the CRCPD's model regulations for electronic brachytherapy
Technical requirements

- Survey for adequate shielding
- Calibrated chamber for the proper energy
- Q.A. check measurements
- Q.M. program: similar to HDR
Authority and responsibilities

- Radiation safety officer
- Authorized User: *physically present at start and during* patient Tx; review patient Tx
- Authorized Medical Physicist (AMP): *physically present at start and during patient Tx*; evaluate eBT output; review calc. prior to Tx; assess each Tx for possible M.E.; establish a Q.A. spot checks
Operating procedures and calibration

- Unit must be FDA approved
- *Unit is secured when not in use*
- Operating and emergency procedures in close proximity to the EBT.
- Survey meter
- Calibration: O.F. *(Within 2%)*; timer accuracy; evaluation of relative dose distribution (5%)
- Source positioning accuracy within 1 mm within the applicator
Spot checks

- Daily spot checks
- AMP to review spot checks within 2 days of completion. Should include indicator lights, cables, catheters or parts of the device
- Dosimetry spot checks: O.F (Dose rate) within 3%; validation of radiation area of the intended area within 1 mm
SAM’s Question 1: When daily spot checks are performed on eBT units by someone other than the AMP, the results must be reviewed by the AMP within:

1. Four days
2. One week
3. One day
4. Two days
5. Three days
When spot checks are performed by someone other than the AMP, the results need to be reviewed by the AMP within:
1) Four days
2) One week
3) One day
4) Two days
5) Three days

Answer: (4)
Reference: AAPM report 152 page 4; section h
Acceptance testing

- Hardware and software
- Inventory and functionality verification
- Interlocks and radiation detectors
- Basic training
- Manufacturer dosimetric data for comparison
Calibrated chamber (energy)
Calibration: in air or water?
Current calibration:
• U.S.: in air (NIST)
• Europe: in water (PTB)
(TG 61 recommendations for both, not there yet!)
Measuring tools: chamber holder (air and water), 1D water tank, plastic water, films etc.
Opportunity to establish daily Q.A. and periodic testing during commissioning
Commissioning

Measurements:
✓ Flatness, symmetry, and penumbra
✓ HVL
✓ Dose rate
✓ Virtual source
✓ PDD
✓ Timer accuracy
✓ Others (Depending on the device)
Example: Esteya commissioning

- Both films and chamber were used
- Surface dose rate (In air TG61, A20)
- PDD measurements (Water and film)
- Virtual SSD (Air, A20)
- Dose profiles (F&S, penumbra etc..) with film
- Accuracy of timer (Independent timer)
- HVL (In air, A20)
Dose rate 2.7 Gy/min @3 mm
X-ray source 69.5 kV, beam current (0.5, 1.0, 1.6 mA)
Profiles similar to Valencia applicators
SSD 60 mm
Five applicators
26 sensors to measure:

- Dose rate
- Flatness and symmetry at depth
- Percent dose at depth

Validated during commissioning!
Work flow for Esteya
(Opportunity for checklist)

Self test → QA check → Add a new patient

Start treatment → Position on surface → Set up treatment plan
Dose Profiles using film dosimetry for all applicators

QA Device
- Dose rate
- Flatness and symmetry ✓
- Percent depth dose
Exradin A20 Chamber vs. TG-61 recommendations

- Parallel-plate chamber with thin window (50.8μm)
- Small collecting volume is 0.0738 cm³
- Collector diameter is 1.93 mm
- Total wall thickness (Full buildup and reduction of Elec. Contamination(TG61)): 7.72 g/cm² vs. 7.3 for 70 kV (Table I TG61)
- Effective point of measurement is at \( dc = 1.80 \) mm depth from the entrance surface (Inverse square corr.)
- Calibrated for energy*
- Negligible stem effect
HVL determination

- Using pure Al layers to determine the HVL
- Geometry (II C, TG61)
- Results: consistent with other findings
Exponential fit for HVL value

HVL Al for 3 cm Applicator using
6 Gy to 0mm (1.6mA)

\( y = 0.2953e^{-0.371x} \)

\( R^2 = 0.9905 \)

HVL = 1.87 mm Al
Polynomial (fourth) fit for HVL

\[ y = 0.0063x^4 - 0.0406x^3 + 0.108x^2 - 0.1892x + 0.3128 \]

\[ R^2 = 0.9999 \]

HVL = 1.69 mm Al
### Dose rate measurements (In air TG61) for 1.6 mA

<table>
<thead>
<tr>
<th>Applicator Size (cm)</th>
<th>Planned Dose Rate (Gy/min)</th>
<th>Measured Dose rate (Gy/min)</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>3.33</td>
<td>3.41</td>
<td>2.46</td>
</tr>
<tr>
<td>2.5</td>
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<td>3.40</td>
<td>3.26</td>
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<td>2.0</td>
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<td>1.5</td>
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</tr>
<tr>
<td>1.0</td>
<td>3.11</td>
<td>3.09</td>
<td>-0.50</td>
</tr>
</tbody>
</table>

Measurements performed for other mA settings (1.0, 0.5)
Virtual SSD

Esteya (S/N 87654321) Virtual SSD 3cm Applicator

\[ \sqrt{\frac{X_0}{X_g}} = 1 + \frac{g}{(SSD + d_c)} \]

\[ y = 0.1657g + 1 \]

SSD = 5.855 cm

58.6 mm vs. 60 mm
PDD measurements in water and with film

- Using A20 in a 1D water tank
- Film using plastic water*
- Scanner: Epson 11000XL
- Software: Film QA PRO2015 from Ashland
- Films: GafChromic EBT2 and EBT3 radiochromic
Measurements of PDD in water

QA Device
- Dose rate
- Flatness and symmetry
- Percent depth dose
PDD results and comparison (3.0 cm applicator)

Esteya (S/N 87654321) 3.0 cm Applicator PDD Comparison
(Normalized to 3mm)

Film: 0-60 mm
A20: 2.8-33 mm
TM34013: 3-10 mm
Internal: 0-5 mm

Percent Depth Dose (PDD)

Depth (mm)
SAM’s Question 2: The A20 chamber meet TG 61 requirements because of the following reason.

1. Chamber orientation
2. Published stem effect data
3. Can be calibrated in air or water
4. Does not require Inverse square law corr.
5. Small collecting volume, negligible stem effect, adequate total wall thickness
The A20 parallel chamber meet TG 61 requirements because of the following reason:

1. Chamber orientation
2. Published stem effect data
3. Can be calibrated in air or water
4. Does not require inverse square law corrections
5. Has a small collecting volume, negligible stem effect, adequate wall thickness

Answer: (5)

Reference: AAPM TG 61, Section V.
Sources of uncertainties

- Film positioning vs. applicator
- Film measurements (PDD): surface dose
- Chamber and applicator positioning for water and air measurement
- Overall uncertainty for dose rate measurement: 3%
Daily Q.A for all components (Cable, applicators, caps, emergency button, Applicator interlock, etc.)
Establish a method of verification for Tx time
Which data to use for Q.A.: own or internal?
Compliance form (Presence of AU and AMP)
Have a template for simulation information to avoid errors (Manual entry)
Pacemaker verification
Others
Independent Tx time verification

Independent calculation for EBT (Esteya) procedure

Patient: __________________ Date: __________

Treatment Area: ____________ Field#: __________

Radiation Oncologist: ______________ Physicist: ______________

Applicator identification (please circle appropriate size):

[Images of applicators: 10 mm, 15 mm, 20 mm, 25 mm, 30 mm]

Hand calculation for treatment time

Use the equation below, the dose per fraction, measured dose rate (Table1), and measured PDD (Table 2) to determine the calculated treatment time.

Calc. Time = \( \frac{\text{Fraction Dose (Gy)}}{\text{Measured Dose Rate (Gy/min) x Measured PDD}} \) = Min

Treatment planning time (from ESTEYA) = Min

Treatment planning time/calculated time X 100=

Acceptable (ratio less than 3%): Y N

Calculated by: __________________ Date: __________

---

<table>
<thead>
<tr>
<th>Applicator diameter (mm)</th>
<th>Dose rate (Gy/min) at 0 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>3.109</td>
</tr>
<tr>
<td>15</td>
<td>3.179</td>
</tr>
<tr>
<td>20</td>
<td>3.248</td>
</tr>
<tr>
<td>25</td>
<td>3.330</td>
</tr>
<tr>
<td>30</td>
<td>3.330</td>
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</table>

Table 1. Measured dose rate for ESTEYA S/N 87654321

<table>
<thead>
<tr>
<th>Applicators sizes (cm)</th>
<th>Depth (mm)</th>
<th>3</th>
<th>2.5</th>
<th>2.0</th>
<th>1.5</th>
<th>1.0</th>
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<tbody>
<tr>
<td></td>
<td>0.0</td>
<td>1.000</td>
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<tr>
<td></td>
<td>0.5</td>
<td>0.968</td>
<td>0.964</td>
<td>0.962</td>
<td>0.967</td>
<td>0.959</td>
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<td>0.937</td>
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<tr>
<td></td>
<td>1.5</td>
<td>0.906</td>
<td>0.900</td>
<td>0.890</td>
<td>0.904</td>
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<tr>
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<tr>
<td></td>
<td>2.5</td>
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<td>0.844</td>
<td>0.824</td>
<td>0.845</td>
<td>0.811</td>
</tr>
<tr>
<td></td>
<td>3.0</td>
<td>0.821</td>
<td>0.818</td>
<td>0.794</td>
<td>0.818</td>
<td>0.778</td>
</tr>
</tbody>
</table>

Table 2. Measured PDD (Film dosimetry) for ESTEYA S/N 8765321 normalized at 0 mm

Example:

Dose/fraction: 7Gy at depth of 3 mm
Applicator size: 30 mm Used current: 1.6 mA

Esteya calculated time: 2:34.3 which is equivalent to = 2.57 min
Calculated time: Dose / (Measured Dose Rate x measured PDD)

7 / (3.330 x 0.821) = 2:33.6 (MIN: 5.55) which is: 2.56 min
(Calculated – Esteya) / calculated x 100 = -0.4%
### Esteya time vs. calculated time*
7 Gy at 3 mm depth

<table>
<thead>
<tr>
<th>Applicator Diameter (cm)</th>
<th>Actual Treatment Time</th>
<th>Calculated Treatment Time* (min)</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>2.57</td>
<td>2.56</td>
<td>-0.45</td>
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<td>2.5</td>
<td>2.61</td>
<td>2.57</td>
<td>-1.53</td>
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<td>2.0</td>
<td>2.65</td>
<td>2.71</td>
<td>2.30</td>
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<td>1.5</td>
<td>2.73</td>
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<tr>
<td>1.0</td>
<td>2.80</td>
<td>2.89</td>
<td>3.24</td>
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</table>

* Using measured dose rate and PDD
Daily treatment verification/Compliance form

Lynn Cancer Institute

Daily Treatment Q.A. for Esteya skin Brachytherapy

Patient Name:
Physician:
Applicator selection (circle appropriate applicator):

10 15 20 25 30

<table>
<thead>
<tr>
<th></th>
<th>Fraction #1</th>
<th>Fraction #2</th>
<th>Fraction #3</th>
<th>Fraction #4</th>
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<tr>
<td>Physician</td>
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<td></td>
</tr>
<tr>
<td>Date</td>
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</table>
Useful beam and geometric miss

Idea from the Valencia group (Jose Perez-Calatayud)
Simulation

Lesion

Useful beam

Plastic cap
Special thanks to:

- Casey Curley (FAU student)
- Resat Aydin (Ashland)
- Regina Fulkerson
- C. Candela-Juan, J. Perez-Calatayud, F. Ballester, Y. Niatsetskii
- S.I. for their support