Intra-operative radiation therapy (IORT)

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IORT refers to a single-fraction treatment delivered to a surgically exposed area

- Electron beam (not discussed here)
- High dose-rate (HDR) Ir-192 afterloader
Advantages:

• The treatment is performed at the time of surgery, when the target area (the tumor bed) is exposed and the applicator can be placed directly over the target.

• Organs at risk may be retracted and shielded as necessary.

• The applicator can be used in virtually any anatomic location (e.g. treatment of colorectal malignancies where the tumor bed is often inaccessible to the cones of a linac based system).

• Avoids cold spots and hot spots often encountered when using the electron beam approach due to angle of beam incidence and field matching.

• Convenience and cost effectiveness.
Afterloading devices:

- Gammamed (Varian Medical Systems, Inc)
- VariSource (Varian Medical Systems, Inc)
- Nucletron, BV
The Harrison-Anderson-Mick applicator (has FDA 510K approval)

- 130-cm source guides embedded at 1-cm spacing in 8-mm thick silastic rubber
- 5 mm from the center of catheter to front, and 3 mm to back (to gain flexibility)
- 2 to 24 catheters
- 22-cm long (can treat up to 20x23 cm²)
- Prescription point 1 cm away from source plane (0.5 cm from the surface)
Mick Radionuclear Instruments, Mt. Vernon, NY
Modified breast HAM
(Mick Radionuclear Instruments)

2-cm total thickness

Prescription at 2 cm from the source plane
IORT prescription:

• Physicist takes oral (rather than written prescription)
• Prescription details should be repeated by physicist and confirmed by physician
• Prescription includes: number of channels (width), length (number of stopping positions), dose and prescription point(s).
### Treatment planning: Prescription / worksheet

<table>
<thead>
<tr>
<th>Treatment Channels (Chₐ, Gv)</th>
<th>GammaMed</th>
<th>Treatment positions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  2  3  4  5  6  7  8  9  10 11 12 13 14 15 16 17 18 19 20 21 22 23 24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>1 = distal (tip of catheter), n = proximal</td>
</tr>
</tbody>
</table>

- Treatment Channels (Chₐ, Gv)
- GammaMed
- Treatment positions

1 = distal (tip of catheter), n = proximal
**IORT Dose specification**

Usually, homogeneous dose is desired throughout the treatment area.

Dose ranges between 15 - 20 Gy at 5 mm in tissue.

Lower dose for pediatric cases: 7.5 -12.5 Gy

Lower dose also used if IORT is combined w/ EBRT: 10 -12.5 Gy

Breast IORT: 20 Gy at 1 cm in tissue

Higher dose prescription has been reported in the literature (30 Gy for biliary / hepatic treatments)

Occasionally, non-uniform dose and irregular treatment geometry may be specified.
**Treatment planning: Standard Geometry**

Template type: IORT H.A.M. - Flat geometry
Offset to first pos.: 0.00 cm
Source travel path: 4.00 cm
Dose ref. line length: 4.00 cm
Points per ref. line: 5
Dose for interior: 10.00 Gy
Stepping distance: 1.00 cm
Treatment planning: Standard Plane
Treatment planning: Breast IORT
Treatment planning: Breast IORT
QA Considerations
Applicator QA

Prior to sterilization: catheter length and integrity, labels

After treatment: applicator integrity

Insure that sterilization does not damage the applicator
QA: Computer Assisted Independent Dose Calculation and Verification

- Input treatment parameters
- Confirm Pt ID, Rx dose, tx site, etc

- 1 Ch # < 19 → yes: vaginal cylinder → yes
  - no: 1 Ch # > 20 → yes: bronchial catheter → yes
    - no: 2 Ch → yes: GYN ring & tandem → yes
      - no: > 2 Ch → yes: HAM IORT

Reconstruct geometry and calculate dose to reference point(s)
The total air kerma strength, $S_k$, needed to deliver dose $D$ at distance $h$ over time $t$ is given by:

$$S_k = \frac{D(Gy)}{10} \cdot \frac{1}{t_{\text{eff}}(h)} \cdot M \left[ A \left( \frac{0.5}{h} \right)^2, 0.5 \right] \left( \frac{h}{0.5} \right)^2 \text{ElongationFact}$$

where:

$$t_{\text{eff}} = \frac{T_{1/2}}{\ln(2)} \left[ 1 - e^{-\frac{\ln(2)}{T_{1/2}} t} \right]$$

and in the case of HDR, the nominal treatment time (s):

$$T = 0.0659 \cdot M \left[ A \left( \frac{0.5}{h} \right)^2, 0.5 \right] \left( \frac{h}{0.5} \right)^2 \exp(0.05[E - 1]^{3/4})$$
Table 1. Manchester System planar implant tables for source strength given either as (equivalent) mass of radium or as air kerma strength. *

<table>
<thead>
<tr>
<th>Area (cm²)</th>
<th>Cumulated source strength to produce 1000 cGy in water</th>
<th>IRAK (cGy cm²)</th>
</tr>
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<td>Milligram hours</td>
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Other precautions:

Remote monitoring of patient and anesthesia equipment
OR stuff remain scrubbed during treatment in case of emergency
In case of emergency the patient can not leave the OR; instead, a shielded enclosure should be provided for the afterloader and source
Personnel requirements

- Physician, Therapist, and two Physicists
- Be aware of the unpredictable timing of IORT
How much it costs:

Initial investment:

✓ shielding (with assoc. structure) 250K
✓ after-loader 200K
✓ planning software 30-50K
✓ applicators (capital investment) up to 25K ea
Running costs:

- Source change + PMI: $12K quarterly
- HAM applicator: ~$100. / ch

With an average of five channels / treatment and one IORT procedure / week, cost / procedure excluding initial investment is roughly $1500.