Brachytherapy: General Principles

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Brachytherapy: The precise answer for tackling cancer

Derives from the Greek word ‘brachy’ – meaning short-distance
Brachytherapy involves placing small radiation sources internally, either into or immediately next to the tumor in a geometrical fashion, allowing precise radiation dose delivery

Treating the cancer ‘from the inside, out’

## Traditional EBRT and Brachytherapy

<table>
<thead>
<tr>
<th></th>
<th>EBRT</th>
<th>Brachytherapy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Treated volume</strong></td>
<td>Large</td>
<td>Small</td>
</tr>
<tr>
<td><strong>Dose distribution</strong></td>
<td>Homogenous</td>
<td>Heterogenous</td>
</tr>
<tr>
<td><strong>Dose rate</strong></td>
<td>High</td>
<td>Variable HDR, LDR, (PDR)</td>
</tr>
<tr>
<td><strong>Fractionation</strong></td>
<td>Multiple</td>
<td>Few</td>
</tr>
<tr>
<td><strong>Treatment duration</strong></td>
<td>Long; weeks to months</td>
<td>Short; hours to days</td>
</tr>
</tbody>
</table>

Key concepts: Dose distribution

Unlike EBRT, brachytherapy is able to deliver a highly conformal dose at a high dose rate.

- Fewer fractions
  - Short treatment
  - Prevents repopulation of cancer cells
  - Limits toxicity to surrounding tissue

Smaller volume + Higher dose = Fewer fractions

Inverse Square Law

Brachytherapy: History

1896
- Radioactivity was described by Becquerel

1898
- Marie Curie extracted radium from pitchblende ore

1901
- Danlos and Bloc performed first radium implant (1901)

1931
- The term brachytherapy proposed first time by Forsell

1940-1970s
- Co$^{60}$, Ta$^{182}$, Cs$^{137}$, Ir$^{192}$ first used in brachytherapy
- Cs$^{137}$ began to replace Ra$^{226}$

1953
- Aterloading technique first introduced by Henschke in New York – removed hazard of radiation exposure. Also Ir-192 used first time by Henschke
Brachytherapy: History

1940-50
- Brachytherapy rules were developed and followed

1953
- LDR brachytherapy became the gold standard

1968
- HDR brachytherapy was introduced

1950s and 1960s
- New radioactive sources, techniques and equipment, which prevented unnecessary radiation exposure to patients and clinicians led to a renaissance for brachytherapy

1970s
- Brachytherapy is established as a safe and effective standard of care for many gynecological cancers

Present day
- Brachytherapy a valued treatment option for many types of cancer, with a wealth of supporting evidence with many advances.

History of Brachytherapy

Rules for implantation were made for LDR

**Interstitial Brachytherapy:**
Manchester system
Quimby System
Memorial System
Paris system

**Surface Mould**
Manchester system

**Intracavitary Brachytherapy:**
Stockholm system (1914)
Paris System (1926)
Manchester System (1938)

Last 4 decades have seen the emergence of remote after loading system (selectron machine – LDR machine – first time used in 1970 for ca cx)
HDR became widely accepted after a long struggle in early 90’s
PDR has been developed
Now with more sophisticated imaging, hardware and software : image based and image guided brachytherapy has come up.
Advantages

1. High dose of radiation is delivered to tumor in short time. So biologically very effective
2. Normal tissue spared due to rapid dose fall off
3. Better tumor control
4. Radiation morbidity minimal
5. Cosmetic superiority over teletherapy
6. Acute reactions appear when treatment is over; so no treatment breaks. Also radiation reactions localized & manageable
7. Treatment time short – reduces risk of tumor repopulation
8. Therapeutic ratio high
9. Also decreased burden on patient & family
Limitations

1. Applicable to *accessible* sites only

2. Application limited to *small size* tumors (T1, T2)
Disadvantages

1. Invasive procedure
2. *Radiation hazard* due to radioisotopes (in olden days due to preloading techniques, now risk decreased)
3. General anesthesia required
4. Dose inhomogeneity is higher than EBRT (but acceptable if rules followed)
5. Because of greater conformity, small errors in source placement can lead to extreme changes from the intended dose distribution
6. Present day brachytherapy is costly
# Types of brachytherapy

**Classification schemes:**

1. depending on use/radionuclide position
2. depending on loading pattern
3. depending on duration of irradiation
4. depending on dose rate
Types of Brachytherapy……

• **Depending on use** (surgical approach to target volume)
  
  o Source in contact with but superficial to tumor:
    
    surface moulds
  
  o **Source inside the tumor/target**
    
    – Interstitial
    – Intracavitary
    – Intraluminal
    – Intravascular
- **Surface dose applications** (plesiocurie/mold therapy)
  - consists of an applicator containing array of radioactive sources designed to deliver a uniform dose distribution to skin/mucosal surface

- **Interstitial brachytherapy**
  - surgically implanting small radioactive sources directly into target tissues

- **Intracavitary brachytherapy**
  - consists of positioning applicators bearing radioactive sources into the body cavity in close proximity to target tissue

- **Transluminal brachytherapy**
  - consists of inserting single line source into a body lumen to treat its surface & adjacent tissue

- **Intravascular brachytherapy**
Types of Brachytherapy……

• Depending on source loading pattern:

  – **Preloaded:** inserting needles/tubes containing radioactive material directly into the tumor

  – **After loaded:** first, the non-radioactive tubes inserted into tumor
    • **Manual:** Ir$^{192}$ wires, sources manipulated into applicator by means of forceps & hand-held tools
    • **Computerized remote controlled after loaded:** consists of pneumatically or motor-driven source transport system
Preloading pattern

• **Advantage:**
  – Loose & flexible system (can be inserted even in distorted cervix)
  – Excellent clinical result
  – Cheap
  – Long term results with least morbidity (due to LDR)

• **Disadvantages:**
  – Hasty application - Improper geometry in dose distribution
  – Loose system – high chance of slipping of applicators – improper geometry
  – Application needed special instruments to maintain distance.
  – Radiation hazard
  – Optimization not possible
After loading pattern

MANUAL AFTERLOADING

Advantages

1. Circumvents radiation protection problems of preloading
2. Allows better applicator placement and verification prior to source placement.
3. Radiation hazard can be minimized in the OT / bystanders as patient loaded in ward.
4. Advantages of preloading remain as practised at LDR.

Disadvantages:

  specialized applicators are required.
APPLICATORS

Gynae Applicators
Vaginal Sorbo
Esophageal Bougie

Nasopharyngeal Applicator
Steel Needles
Plastic Catheters & Buttons
REMOTE AFTERLOADING
Advantages:
1. No radiation hazard
2. Accurate applicator placement
   - ideal geometry maintained
   - dose homogeneity achieved
   - better dose distribution
3. Information on source positions available
4. Individualization & optimization of treatment possible
5. Higher precision, better control
6. Decreased treatment time - opd treatment possible
7. Chances of source loss nil.

Disadvantages:
1. Costly
2. Still some grey areas in dose conversions
Afterloading Systems

Selectron MDR

Microselectron, Varies Source & Gammamed
Types of Brachytherapy......

Depending on Dose-Rate used

Acc. To ICRU REPORT no.38 :

- **Low dose rate (LDR):** 0.4-2 Gy/hour
  
  Hours to days- Confinement to bed
  
  LDR A/L: 1970s using Cs\(^{137}\)

- **Medium dose rate (MDR):** 2-12 Gy/hour
  
  in Mid 70s Cs137-

- **High dose rate (HDR):** >12 Gy/hour (0.2 Gy/min)
  
  1\(^{st}\) in 1968-joslin (cathetron)
  
  1984-PGI
  
  (Co\(^{60}\) source drawn to high intensity)

- **Ultra-low dose rate (ULDR):** 0.01-0.3 Gy/hour
LDR-advantages

1. **Clinical effects** – predictable
   - large body of data spanning 4-5 decades
   - experience with various radionuclides

2. **Radiobiologically superior**
   - allows continuous radiation to tumor as well as simultaneous repair of sublethal damage in normal tissues

3. **Long experience**
   - well defined rules for use exist which allow optimum implant dosimetry

4. **Less morbidity & best tumor control**

5. **Cheap**

6. **Since 1-2 sessions required**
   - intersession variability in dose distribution minimized
LDR-disadvantages

1. Treatment continuous and prolonged.  
   - confined to bed
2. Geometry and distribution not properly maintained
3. Limited applicability in elderly patients, with  
   respiratory, cardiac problems
4. Individualization & optimization not possible
MDR

ADVANTAGES :
1. treatment completed in shorter treatment time
2. increased patient convenience
3. considered radiobiologically nearer to LDR brachytherapy

DISADVANTAGES :
1. without correction, increased incidence of late complication (20 – 30 %)
2. few results despite widespread use at one time
1. Shorter treatment times, resulting in:

   a) OPD based treatment possible
   b) Less patient discomfort
      (prolonged bed rest is eliminated)
   c) Reduced applicator movement during therapy (geometry well maintained)
   d) Greater displacement of nearby normal tissues.
   e) Possibility of treating larger number of patients
2. **Allows use of smaller & thinner applicators than are used in LDR:**
   a) Resulting in lesser tissue trauma
   b) Reducing the need for dilatation of the cervix and therefore reducing the need for heavy sedation or general anesthesia (allowing treatment for high-risk patients who are unable to tolerate general anesthesia).
   c) Geometrical sparing can circumvent radio biological disadvantage

3. **Tailor dose distribution to target through optimization** due to stepping source technique used.

4. **Elimination of exposure to personnel**
HDR-disadvantages

1. Decreased therapeutic ratio
   - short treatment time—doesn’t allow repair of sublethal damage to normal tissues and redistribution & reoxygenation of tumor cells (radiobiologically inferior as normal tissue becomes more sensitive)

2. Multiple sessions
   - different geometry each time

3. Less time to detect & correct error

4. Limited experience
   - till recently, no standard guidelines

5. Economic disadvantage
   - Labour intensive
   - large capital investment
PDR Brachytherapy

- Series of short HDR treatments (10 minute pulse repeated at 1 hr intervals) replacing the continuous LDR treatment lasting several days - PDR BT.
- Overall time remains same as LDR
- Source strength: 1 Ci
- ADVANTAGE:
  radiobiologically nearer to LDR
  optimization possible
Types of Brachytherapy......

• Depending upon means of controlling dose delivered (duration of irradiation)
  – Temporary/Removable implants
    when the radioactive source implanted into the tumor tissue is allowed to remain there for definite period. Ex Cs$^{137}$, Ir$^{192}$
  – Permanent implants
    when the sources are implanted indefinitely ex: Pd$^{103}$, Au$^{198}$
These terms used for interstitial form of brachytherapy
Permanent implant

Advantages:

1. Useful for less accessible sites (e.g. prostate, endovascular)
2. Allows a continuous ultra-low dose rate treatment (maximum biological effectiveness)
3. Allows better normal tissue healing due to low dose rate
4. Cell kill predominantly by alpha damage (KeV photons, PE effect) – better efficacy in slow growing and radio-resistant tumors.
5. Patient mobility maintained after procedure
Disadvantages:

1. Radiation protection issues in case of source being excreted (e.g. urine)
2. Dosimetry uncertain due to short half life – latter part of treatment becomes progressively less effective
3. Source migrations known to occur – resultant perturbation in dose distributions
4. Sources expensive – can’t be reused.
5. Complicated implant procedure – difficult to maintain geometry esp. for larger tumors.
6. Radiobiologically inferior in rapidly proliferating tumors
Radioactive sources

- **Obsolete or historical**
  - $^{226}$Ra, $^{222}$Rn
- **Currently used sealed sources**
  - $^{137}$Cs, $^{192}$Ir, $^{60}$Co, $^{125}$I, $^{103}$Pd, $^{198}$Au, $^{90}$Sr.
- **Developmental sealed sources**
  - $^{241}$Am, $^{169}$Yb, $^{252}$Cf, $^{131}$Cs, $^{145}$Sm.
Characteristics of a radioisotope

- **Half life** - Time required for the activity of the source to decay to half the initial value.
- **Gamma energy**
- **Specific activity** - Activity per unit mass of a radio nuclide. (Ci/gm)
- **Half value layer** - Thickness of the material required to decrease the intensity of the incident beam to half of its original value.
- **Exposure rate constant** - Gamma ray constant
  Defined as the exposure in R/hr at a point 1 cm from a 1 mCi point source. (R cm²/hr/mCi)
- **Beta Energy & filtration**
What is an Ideal Radionuclide?

• Easily available & Cost effective
• Gamma ray energy high enough to avoid increased energy deposition in bone by PEE & low enough to minimise radiation protection requirements
  • Preferably monoenergetic: Optimum 300 KeV to 400 KeV(max=600 kev)
• Absence of charged particle emission or it should be easily screened (Beta energy as low as possible: filtration)
• Half life such that correction for decay during treatment is minimal
  – Moderate (few years) T1/2 for removable implants
  – Shorter T1/2 for permanent implants
• Moderate gamma ray constant (determines activity & output) & also determine shielding required.
What is an Ideal Radionuclide?

- **No daughter product;** No gaseous disintegration product to prevent physical damage to source and to avoid source contamination
- **High Specific Activity (Ci/gm)** to allow fabrication of smaller sources & to achieve higher output (adequate photon yield)
- **Material available** is insoluble & non-toxic form
- **Sources can be made in** different shapes & sizes: Tubes, needle, wire, rod, beads etc.
- **Should withstand sterilization process**
- **Disposable without** radiation hazard to environment
- **Isotropic:** same magnitude in all directions
  - around the source
- **No self attenuation**
Why Ra not used now?

- **Spectrum** has >8 photon energies ranging from 0.047-2.45 MeV: gives heterogenous beam & non uniform dose distribution
- **Low specific activity**: 1 Ci/gm: large dia of needles will be needed
- **High gamma ray constant**: requires more protection
- **High energy**: large HVL reqd: high radiation shielding will be reqd
- **Rn 222 being the gaseous daughter product**: threat of leaks especially from long bent needles (long t1/2)
- **Storage & disposal** of leaked sources a big problem
- **Ra source costly**
RADIUM SUBSTITUTES

Currently used sealed sources

<table>
<thead>
<tr>
<th>Element</th>
<th>Energy (MeV)</th>
<th>Half-life</th>
<th>HVL-Lead (mm)</th>
<th>Exposure rate constant</th>
<th>Source Form</th>
<th>Clinical application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cesium Cs¹³⁷</td>
<td>0.662</td>
<td>30 yrs</td>
<td>6.5</td>
<td>3.28</td>
<td>Tubes &amp; Needles</td>
<td>LDR I/C &amp; temporary Implants</td>
</tr>
<tr>
<td>Cobalt Co⁶⁰</td>
<td>1.25 average</td>
<td>5.26 yrs</td>
<td>11</td>
<td>13.07</td>
<td>Encapsulated spheres</td>
<td>HDR I/C</td>
</tr>
</tbody>
</table>

Cesium or Cobalt needles, Tubes & Pallets
Currently used sealed sources

<table>
<thead>
<tr>
<th>Element</th>
<th>Energy (MeV)</th>
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<th>HVL-Lead (mm)</th>
<th>Exposure rate constant</th>
<th>Source Form</th>
<th>Clinical application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iridium Ir\textsuperscript{192}</td>
<td>0.397 average</td>
<td>73.8 days</td>
<td>6</td>
<td>4.69</td>
<td>Seeds in nylon ribbons; Metal wires; Encapsulated source on cable</td>
<td>LDR &amp; HDR temporary implants HDR I/C Intravascular</td>
</tr>
</tbody>
</table>

- [A] Sheath
- [B] Hairpin
- [C] Single pin
- [D] Encapsulated source on cable
- [E] Intravascular

![Diagram of Iridium source configurations](image)
Ir-192 near ideal radioisotope?

- Compatible with after loading techniques
- Ideal energy (0.3 – 0.4 Mev) – monoenergetic – more radiobiological effect
- Flexible & malleable – can be used in form of wires of any size
- Energy is low – thinner shields reqd for radiation safety
- $\beta$ energy is low – so lesser filtration reqd
- No products
- Easily available, less costly

Limitation
Short half life so source has to be replaced every 3 months
### Currently used Seed sources

<table>
<thead>
<tr>
<th>Element</th>
<th>Energy (MeV)</th>
<th>Half-life</th>
<th>HVL-Lead (mm)</th>
<th>Exposure rate constant</th>
<th>Source Form</th>
<th>Clinical application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold Au(^{198})</td>
<td>0.412</td>
<td>2.7 days</td>
<td>6</td>
<td>2.35</td>
<td>Seeds</td>
<td>Permanent Implants</td>
</tr>
<tr>
<td>Iodine I(^{125})</td>
<td>0.028</td>
<td>59.6 days</td>
<td>0.025</td>
<td>1.45</td>
<td>Seeds</td>
<td>Permanent Implants</td>
</tr>
<tr>
<td>Palladium Pd(^{103})</td>
<td>0.020</td>
<td>17 days</td>
<td>0.013</td>
<td>1.48</td>
<td>Seeds</td>
<td>Permanent Implants</td>
</tr>
</tbody>
</table>
# Newer Isotopes

<table>
<thead>
<tr>
<th>Name</th>
<th>$T_{1/2}$</th>
<th>Photon energy (KeV)</th>
<th>$10^{th}$ VL</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samarium 125</td>
<td>340 days</td>
<td>41</td>
<td>0.2</td>
<td>Sensitization of cells to radiation damage by iodinated deoxyuridine due to photon energy</td>
</tr>
<tr>
<td>Americium 241</td>
<td>432 yrs</td>
<td>60</td>
<td>0.42</td>
<td>Low specific activity and $\alpha$ emitter</td>
</tr>
<tr>
<td>Ytterbium 169</td>
<td>32 days</td>
<td>93</td>
<td>1.6</td>
<td>Highest specific activity and lower tissue attenuation</td>
</tr>
<tr>
<td>Californium 252</td>
<td>2.65 yrs</td>
<td>NA</td>
<td>NA</td>
<td>Neutron emitter used in brachytherapy and as EBRT source. $2.3 \times 10^9$ / sec (neutrons)</td>
</tr>
</tbody>
</table>
SOURCE FORMS

- Needle
- Tube
- Wire
- Hair pin
- Cylinder
- spherical
- Beads
- Pellets
- Micro pellets
## Radio-isotopes Used in Radiotherapy and their Physical Characteristics

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Radio-Isotope</th>
<th>$\gamma$-Energy (MeV)</th>
<th>$\beta$-Energy (MeV)</th>
<th>Gamma Constant</th>
<th>Half Life</th>
<th>HVL (Pb)</th>
<th>Form</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ra-226</td>
<td>0.047-2.44</td>
<td>0.017-3.26</td>
<td>8.25 R</td>
<td>1620 yrs.</td>
<td>1.4</td>
<td>Needles, tubes</td>
<td>I/C, Mould, Ints.</td>
</tr>
<tr>
<td>2.</td>
<td>Rn-222</td>
<td>0.047-2.44</td>
<td>0.017-3.26</td>
<td>8.25 R</td>
<td>3.8 yrs.</td>
<td>1.2</td>
<td>Seeds</td>
<td>Ints.</td>
</tr>
<tr>
<td>3.</td>
<td>Tn-182</td>
<td>0.043-1.45</td>
<td>0.18-0.514</td>
<td>6.71R</td>
<td>115 days</td>
<td>1.2</td>
<td>Wires, pins, ribbon</td>
<td>Ints.</td>
</tr>
<tr>
<td>4.</td>
<td>Co-60</td>
<td>1.17-1.33</td>
<td>0.313</td>
<td>13.25R</td>
<td>5.2 yrs.</td>
<td>1.2</td>
<td>Needles, tubes, teletherapy sources</td>
<td>I/C, Mould, Ints., I/L</td>
</tr>
<tr>
<td>5.</td>
<td>Cs-137</td>
<td>0.33</td>
<td>0.52-1.17</td>
<td>3.22 R</td>
<td>30 yrs</td>
<td>0.65</td>
<td>Needles, tubes, pallets</td>
<td>-do-</td>
</tr>
<tr>
<td>6.</td>
<td>Ir-192</td>
<td>0.3.06</td>
<td>0.24-0.67</td>
<td>4.62 R</td>
<td>74.2 days</td>
<td>0.30</td>
<td>Wires, seeds, ribbons</td>
<td>-do-</td>
</tr>
<tr>
<td>7.</td>
<td>I-125</td>
<td>0.035</td>
<td>None</td>
<td>1.20 R</td>
<td>60.2 days</td>
<td>0.0</td>
<td>Seeds</td>
<td>Ints.</td>
</tr>
<tr>
<td>8.</td>
<td>An-198</td>
<td>0.4-1.08</td>
<td>0.96</td>
<td>2.32 R</td>
<td>2.7 days</td>
<td>0.33</td>
<td>Seeds</td>
<td>Ints.</td>
</tr>
<tr>
<td>9.</td>
<td>P-32</td>
<td>None</td>
<td>1.71</td>
<td>--</td>
<td>14.3 days</td>
<td>0.01</td>
<td>Plaques</td>
<td>I/V Stent</td>
</tr>
</tbody>
</table>

I/C – Intracavitary, Ints. – Interstitial, I/L – Intraluminal, I/V – Intra-vascular
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Radio-Isotope</th>
<th>γ-Energy (MeV)</th>
<th>β-Energy (MeV)</th>
<th>Gamma Constant</th>
<th>Half Life</th>
<th>HVL (Pb)</th>
<th>Form</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.</td>
<td>Sr-90</td>
<td>None</td>
<td>0.54-2.27</td>
<td>--</td>
<td>28.9 yrs</td>
<td>0.01</td>
<td>Plaques</td>
<td>Plaque</td>
</tr>
<tr>
<td>11.</td>
<td>Cr-252</td>
<td>1.5 &amp; 1.0 Neutron 2.1 &amp; 2.3</td>
<td>--</td>
<td>--</td>
<td>54 yrs</td>
<td>--</td>
<td>Tubes</td>
<td>I/C</td>
</tr>
<tr>
<td>12.</td>
<td>Pd-103</td>
<td>0.21 (mean) 0.02-0.497</td>
<td>--</td>
<td>--</td>
<td>17 days</td>
<td>0.03 mm</td>
<td>Seeds</td>
<td>Ints.</td>
</tr>
<tr>
<td>13.</td>
<td>Sm-145</td>
<td>0.041 (mean) 0.038-0.061</td>
<td>--</td>
<td>--</td>
<td>340 days</td>
<td>0.2 mm</td>
<td>--</td>
<td>-do-</td>
</tr>
<tr>
<td>14.</td>
<td>Am-241</td>
<td>0.060 (mean) 0.014-0.059</td>
<td>--</td>
<td>--</td>
<td>432 days</td>
<td>0.42 mm</td>
<td>--</td>
<td>-do-</td>
</tr>
<tr>
<td>15.</td>
<td>Yt-169</td>
<td>0.093 (mean) 0.050-0.0307</td>
<td>--</td>
<td>--</td>
<td>32 days</td>
<td>3.3 mm</td>
<td>--</td>
<td>-do-</td>
</tr>
</tbody>
</table>

I/C – Intracavitary, Ints. – Interstitial, I/L – Intraluminal, I/V – Intra-vascular
Source Strength Specification: Quantities and Units

Quantity and Units :-
1. mg Radium or mg radium equivalent.
2. mg hours
3. Roentzen
4. Rads or Centigray

Activity :-
1. Curie or mCi
2. Air kerma strength

Dose Calculations :-
1. Lane’s approximation
2. Sievert integral
3. Computer dose calculations.
Radiation Safety

Radiation Shield

Radio-isotop
Calibration of Sources

Well Type Chamber
Calibration of Sources

Zigs
Clinical criteria for brachytherapy

1. *Small size* tumors (3 – 5 cm)
2. Depth of penetration/thickness < 1.5 – 2 cm
3. Histology: moderately *radiosensitive* tumors (ca squamous cell); some adenocarcinomas
4. *Early stage* (localized to organ)
5. No nodal/distant metastasis
6. Location: *accessible* site with relatively maintained anatomy
7. Absence of local infection & inflammation
Indications

• For radical radiation alone:
  – Skin tumors
  – Head and Neck cancer – Oral Cavity
  – Cervical cancer
  – Prostate cancer
  – Penile cancers
  – Ocular tumors
  – Breast cancer

• As a boost after EBRT ± Chemotherapy:
  – Head and neck cancers – Oral Cancer
  – Cervical cancers
  – Breast cancer
  – Esophagus
  – Anal canal
Indications

• **In the post-operative setting:**
  – **Perioperative:**
    • Soft tissue sarcomas
    • Breast
  – **Postoperative:**
    • Endometrium
    • Cervix
    • Breast

• **Palliative setting:**
  – Bronchus
  – Bile ducts
  – Selected esophagus
  – Selected recurrent tumors (chest wall, head and neck)

• **Benign tumors:**
  – Keloids
  – Pterygium

• **Other indication:**
  – Endovascular brachytherapy
  – Radioactive stents
Brachytherapy offers a precise, highly effective and well tolerated treatment option tailored to the needs of individual patients.

Brachytherapy: Incorporating advanced imaging and computing technology into planning and treatment

2D Film – Based
Standardization through protocols – Paris system (e.g. breast) and Manchester method (gyn)

3D Volume – Based
Dose/volume optimization with availability of 3D imaging capabilities (CT/MRI)

Dynamic (real-time) dose based placement guidance
Image-guided adaptive brachytherapy

Image-guided planning and delivery

Advanced imaging used for virtually every step of the procedure

Provisional treatment planning
Simulation of treatment and provisional dose calculation

Quality control of dose delivery
During or after procedure

Definitive treatment planning
3D virtual patient and optimization of treatment plan

Image-guided application
Accurate placement of applicators

Precision Therapy

Delivering precision treatment

Brachytherapy delivers targeted radiation through the combination of computer-based planning, imagery and treatment delivery techniques via specialized applicators.

- **Imaging**: Clinical examination and tumor imaging
- **Application insertion**: Source applicators placed in body for accurate positioning
- **Optimizing treatment plan**: Create virtual patient via visualization and refine
- **Delivery**: Sources delivered to treatment site via applicators
Brachytherapy - A multidisciplinary approach

Collaborative multi-disciplinary team, providing patient-centred care
Thank You