Brachytherapy
The Dawn

SK Shrivastava et al.
Department of Radiation Oncology & Medical Physics
Tata Memorial Hospital, Parel, Mumbai
Henry Becquerel, a French physicist accidently discovered radioactivity. Uranium caused black spot on photographic film.”
The various reasons we have just enumerated lead us to believe that the new radioactive substance contains a new element to which we propose to give the name of RADIUM.

...was announced by Marie and Pierre Curie at the meeting of the Academy of Science in Paris on December 26, 1898. It took another 45 months, however, before the Curies were able to prepare a tiny amount of pure radium and determine its atomic weight to be 226.
St. Joachimstal mines, Bohemia

• 1523+ Silver coin (Thaler = $),
• 16+: Ni, Bi, Uranium
• 1873: Great Fire
• 19+: Ra & Radon Spa
• WW2: Germans to Czechs
• Uranium mining ceased 1964
• Radioactive thermal springs Rheum.
• Average life expectancy 42 years
Early Publications

1896: UK – *British Medical Journal* –
1900: Gr – *Photographische Rundschau* – F. Walkoff & F. Giesel

1901: Fr – *Comptes rendus* – Pierre Curie
1903: US – *Colorado Medical Record* – George Stover
1903: Fr – *Annales Dermatologie et Syphilologie* – Henri Danlos & Paul Bloch
1903: Gr – *Deutsche Medizinische Zeitung* – Herman Strebel
1903: Rus – *Dermatologischka Zeitschrift* – Semen Goldberg
1904: US – *New York Medical Record* – Robert Abbé
1904: US – *JAMA* – Williams Rollins
1905: Gr – *Archives of Roentgen Ray* – F. Giesel

Lesions treated: lupus vulgaris, eczema, keloid, rodent ulcer, epidermoid & breast ca.

1910: Fr – *Radiumtherapy (textbook)* – Louis Wickham & Paul Degrais
Entitlements

- German Radium *(Buchler Company, Brunschweig)*
- French Radium *(Armrt de Lisle, Paris)*

- *The Rarest Substance* (sold with title in UK)
- *Dawn of a Miracle* (sold as title in USA)

- The Romance of Radium (Movie) 1937
- The Trail of Invisible Light (Book) 1965
Brachytherapy

Intracavitary

Interstitial

Surface Moulds
Madame Marie Curie discovered radium in 1896.
Just two years later, a vial of radium salt was placed on the breast of a woman with cancer, and the tumor was observed to shrink. This was the first use of interstitial brachytherapy.

Dr. Keynes' technique of inserting radium 1920.
A Record of a Course of Intracavitary Brachytherapy as delivered by Hugh Hampton Young
In 1914, Stevenson and Joly improved the technique. Using pure radium sulphate, thus manufacturing the first radium “needles” made from steel or platinum.

Dr Failla at Memorial Hospital, collected radon gas in tiny glass tubes that were then inserted into tumours and left there indefinitely.
1900: Friedrich Walkoff & Friedrich Giesel (Germany) radiation burn

1901: Dr Henri Danlos & Paul Bloch, French doctor (St Louis Hospital, Paris) 0.39 Gm Radium treated lupus skin lesion & Dr Robert Abbe, Surgeon (St Lukes & Memorial Hospital, New York) used radium for patients

1903-1950: Margaret Cleves (Ca Cervix), Hugh Young (Ca Prostate), Geoffrey Keynes (Ca Breast)

1960: After-loaders (E. Henschke)

1990: Imaging – CT, MRT

2000: Advanced computerized - 3D presentations

2005: Robotic delivery of prostate seed

1901-1950

• Pierre Curie studied the effect of radiation
Mile stones - Brachytherapy

1896 – Becquerel - Radioactivity
1898 – Madam Curie / Pierre Curie - Radium
1903 – Nobel Prize for Curie’s & Becquerel
1903 – First successful case of malignancy basal cell carcinoma of face
1920 – Patterson & Parker tables for Radium
1920 – Paris system of IC Rx / Stockholm System
1934 – Manchester System
1953 – Tod & Meridith point A & B defined
1957 – Ir-192 in implants
1960 – Preloaded applicators Stockholm, Paris & Manchester
1960 – After-loading applicator - Henchke / Fletcher-suit
1962 – First Remote after-loading machine
1965 – Paris system – Interstitial
1970 – Co-60 HDR
1985 – HDR Ir-192
2000 – 3D Brachy planning, CT/MR Compatible appl., Inverse planning
BRACHYTHERAPY DOSIMETRY

Early treatments of Radium - No physical or biological basis, empirical

INTRACAVITORY BRACHYTHERAPY

1911: Stockholm System - Forsell
  2 -3 applications at 3 weekly intervals, each lasting 27-30 hrs.

1919: Paris System - Regaud
  1 application over 6-8 days

1934: Manchester System - Paterson & Parker
  8000 R to point A, over 140 hrs. divided in 2 equal applications
BRACHYTHERAPY DOSIMETRY

INTERSTITIAL BRACHYTHERAPY

Manchester System (Paterson - Parker):
milligram hours of Radium needed to deliver 1000R planar & volume implants
surface moulds
differential activity

Paris System (Pierquin- Deuterix):
Iridium-192 as isotope
Reference isodose: 85% of basal dose rate
Equidistant, parallel, rectilinear radioactive lines
Equal linear activity
BRACHYTHERAPY DOSIMETRY

INTERSTITIAL BRACHYTHERAPY

Quimby System:

Uniform distribution of sources of equal linear activity
non uniform distribution, higher in the central region of the treatment volume

Memorial System:

Extension of the Quimby System
Complete dose distributions around lattices of point sources of uniform strength spaced 1 cm. Apart
Computer generated dose distributions
BRACHYTHERAPY DOSIMETRY

INTERSTITIAL BRACHYTHERAPY

Computer Dosimetry System:

Development of advanced treatment planning computers
Flexibility to deviate from established dosimetry systems
Optimise isodose distributions according to clinical needs
May try to compensate for poor implant geometry

Stepping Source Dosimetry Systems:

Evolution of HDR & PDR systems
High activity, single, miniaturised source
Dwell time is a function of prescribed dose, geometry of the application and source strength on the day of application.
Prostate brachytherapy

Radium sources

Prominent urologist. The leading innovator was Benjamin Barringer, who performed hundreds of transperineal implants beginning in 1915.
The needles inserted into the gland until the tips can be sensed.
Young initially reported dramatic results, with “amazing resorption of extensive carcinomatous involvement of prostate and seminal vesicles… in the majority of cases,” resulting in the “disappearance of pain and obstruction.. which is indeed remarkable.” 3.4
The first generation of Mick® applicators were developed in 1973.

Seeds were contained in shielded cartridges.

Applicator designed according to “afterloading principle” of Ulrich Henschke.
Gold Radon-Bearing Seeds
Brachytherapy

- Low Dose Rate (LDR) < 2 Gy/hr
- Medium Dose Rate (MDR) 2-12 Gy/hr
- High Dose Rate (HDR) > 12 Gy/hr
- Pulse Dose Rate (PDR)
Afterloading techniques
Ulrich Henschke 1960

Figure 3. Illustration of early single-channel remote afterloading system (Walstam 1962). An LDR source train at the end of a flexible capable was used to move the source to and from the patient to a shielded safe under control of an automatic timer. A radiation detector was used to verify source position.
Remote After-loading

- Remote afterloading was first introduced by Walstam and Henschke et al in early 1960s for LDR and MDR Intracavitary BT.
- O’Connell in 1965 introduced High dose rate Brachytherapy by using Co60 pellets in which fractionated treatment lasting only few minutes administered.
- In 1970 first SSS RAL was introduced by Gauwerky 1977 and Schulze et al 1984 by using high intensity minitiaurized Ir-192 sources welded onto the end of flexible cable drive.
It was suggested to consider treating early breast cancer with brachytherapy after removal of the visible cancer mass (lumpectomy). This technique of removing the large mass and treating the surrounding area with brachytherapy was an accepted technique for sarcomas,
## Dosimetry Planning: Major Differences

<table>
<thead>
<tr>
<th></th>
<th>2D planning</th>
<th>3D planning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reconstruction</strong></td>
<td>Orthogonal radiographs</td>
<td>CT/MR images</td>
</tr>
<tr>
<td><strong>Source positions</strong></td>
<td>BTB distance on radiographs</td>
<td>Target volume from CT/MR images</td>
</tr>
<tr>
<td><strong>Dose prescription</strong></td>
<td>point A, Basal points</td>
<td>target volume</td>
</tr>
<tr>
<td><strong>Volumes</strong></td>
<td>No volumes or describe only tumor volumes</td>
<td>• tumor and OAR volumes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• CTV splits into HR CTV, IR CTV, LR CTV for ICA</td>
</tr>
<tr>
<td><strong>Dose optimization</strong></td>
<td>base on dose points, isodose shape</td>
<td>base on dose points, isodose shape and coverage, DVH</td>
</tr>
<tr>
<td><strong>Dose reporting</strong></td>
<td>Point A, bladder, rectum, shape ref isodose</td>
<td>Same as in 2D + other volumes specs</td>
</tr>
<tr>
<td>Year</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>1941</td>
<td>Radon Seeds</td>
<td></td>
</tr>
<tr>
<td>1960</td>
<td>Preloaded Cesium137/Cobalt-60 capsules</td>
<td></td>
</tr>
<tr>
<td>1962</td>
<td>Gold-192 grains</td>
<td></td>
</tr>
<tr>
<td>1972</td>
<td>Manual after-loading Cobalt-60</td>
<td></td>
</tr>
<tr>
<td>1976</td>
<td>Cesium-137 tubes (BARC)</td>
<td></td>
</tr>
<tr>
<td>1979</td>
<td>Cesium137 tubes/needles (Amersham)</td>
<td></td>
</tr>
</tbody>
</table>
| 1981 | Selectron LDR/MDR – Cs-137  
Manual after-loading Iridium-192 |
| 1987 | microSelectron LDR – Ir-192 |
| 1994 | microSelectron-HDR, TPS – PLATO |
| 1999 | microSelectron-HDR control console & PLATO up-gradation |
| 2003 | microSelectron console up-gradation |
| 2005 | PLATO up-gradation. Sunrise workstation, MRI comp. applicator |
| 2006 | Digitally networked C-Arm in OT |
| 2008 | USG in OT, use MRI volume delineation |
Brachytherapy
CARCINOMA OF CERVIX
Intracavitary Brachytherapy
INTERSTITIAL BRACHYTHERAPY FOR SOFT TISSUE SARCOMA
IORT (Intra-Operative Radiation Therapy): Brachytherapy

- Direct radiation to the target volume
- Minimizing dose to underlying normal tissues
- Local dose escalation
- Organ function preservation

Sites:
- Extremities
- Head & Neck
- Pelvis
- Gastric, Pancreatic
- Lung, Liver, Kidneys
- CNS
IORT (Intra-Operative Radiation Therapy): Brachytherapy

**Advantages**

- Tissue at risk is defined and visualised
- Minimize margins
- Vital adjoining structures moved out
- Useful as boost
- ? Useful for re-irradiation
- Adjuvant approaches (Hyperthermia, Chemo, radiosensitizers use)

**Limitations:**

- Size limited generally <5x5 cm
- Not suitable in widely un-resectable tumors
- Personal exposure (permanent implants)
XI – ICRO/AROI PG Teaching Course
TMH, Mumbai

- Physics
- Radiobiology
- **GYN Cancers:** Intracavitary, Image guided brachytherapy
- Soft Tissue Sarcomas
- **Breast Cancer:** APBI, Boost
- **GI malignancy:** Perineal approach, Intraluminal
- **Head & Neck:** Surface mould, Oral cavity

**Evaluation**
A Tribute to Dr. KA Dinshaw
16 November 1943 – 26 August 2011
Thank You