ANATOMIC MODIFICATION

May 18, 2019
Thomas M. Schroeder, MD
University of New Mexico
Outline

• History of Challenges in External Beam Radiation Therapy
• Concept of Anatomic Modification
• Examples of Anatomic Modification
• Questions
Financial Disclosure

Sadly – none.
External Beam Radiation

Concept was simple from the start

• Radiate the tumor
• Don’t radiate the other stuff

Challenges

• Where’s it going?
• How much are we giving?
• Where’s the tumor?
• How do we get it there?
• Does this patient need it?
External Beam Radiation Challenges

- What are these mysterious X-rays?
- Dose at Depth
- Computed Tomography & the Personal Computer
- Where are we aiming?
What are these X-rays?

- 1895 Roentgen Announce Discovery of X-rays
- 1896 Emil Grubbe after burning his own hand with repeated exposures of radiation, he radiated Rosa Lee; a patient with a chestwall recurrence of breast cancer using lead to shield uninvolved areas – not published until the early 1900s (debated)
- 1904 Clarence Dally died of metastatic squamous cell carcinoma of the skin after repeated exposures to x-rays under the employ of Thomas Edison.
- 1953 Watson & Crick - structure of DNA
- 1953 ICRU recommended the rad, equal to 100 erg/g as the unit of absorbed radiation dose
- ~60 years of radiation therapy before we recommend a unit of measurement

https://www.pbs.org/newshour/health/emil-grubbe-first-use-radiation-treat-breast-cancer
Dose at Depth

- ~1870 X-ray tubes – Crookes Tube (<1-10kEV?)
- 1930s X-ray Filters harden the beam for dose at depth and Supervoltage therapy (100keV)
- 1949 Harold E. Jones Co60 Teletherapy (1.25 MeV), clinical use 1960s – 1970s
- 1947 William W. Hansen - first 6MeV linac (6 MeV)
- 1953 First Linac treatment of a patient in London, clinical use 1970s – present day
- Linac energies increase from 6MeV to 25+MeV
- 1946 Proton therapy suggested by Robert R. Wilson
- Clatterbridge Centre for Oncology, UK opened first clinical proton center for ocular tumors.
The CT & The PC

• 1971 Medical use of CT imaging, London. Invented by Hounsfield and independently Cormak
• 1980s Personal Computers propagate across the world
• CTs provide a three-dimensional map and PCs provide computational power to visualize the radiation dose on that CT anatomy
• 1990s – present. CTs and PCs provide the foundation for a continuous steady improvement in external beam radiation therapy devices
• Higher energy photons abandoned for complex multi-directional and rotational treatments with lower energies using intensity modulation, inverse planning, dynamic apertures (MLCs), helical treatments, …
Where are we aiming?

Targeting the Patient on the Table

• Port Films (early on with radiation therapy)
• Ultrasound Guidance (late 1990s)
• 2002 Cone Beam CT (William Beaumont), clinical use ~2005 to current
• 2004 MR guided radiation conceived, 2014 Siteman cancer center treats first patient with MR guided cobalt device (ViewRay MRIdian)
• Dynamic targeting (account for motion) with plan adaptation (account for tumor changes) will occur on the table.

Anatomic Modification

• Concept – modify the anatomy to improve the therapeutic ratio (move stuff around so you can better radiate the tumor and not the patient)
• Intuitive – e.g. move arm up to radiate the breast
• Early example – Margaret Cleaves suggest using gauze to displace bladder & rectum in cervical brachytherapy (1903)
• Belly Board – allows small intestines to fall away from the pelvis to facilitate avoidance 1980s
• Lupectomy Clips – clips in the breast lumpectomy sites to facilitate smaller margins.
Anatomic Modification

- Concept – modify the anatomy to improve the therapeutic ratio (move stuff around so you can better radiate the tumor and not the patient)
- Intuitive – e.g. move arm up to radiate the breast
- Early example – Margaret Cleaves suggest using gauze to displace bladder & rectum in cervical brachytherapy (1903)
- Belly Board – allows small intestines to fall away from the pelvis to facilitate less dose to small bowel.
- Lupectomy Clips – clips in the breast lumpectomy sites to facilitate smaller margins.
Prevention of radiation enteritis in children, using a pelvic mesh sling.


Author information

Abstract

Between 1986 and 1991, the authors used polyglycolic acid mesh slings (placed at or above the sacral promontory) in eight children with pelvic malignancies to exclude all small bowel from the pelvis during pelvic radiation therapy. The only complications of this treatment were prolonged postoperative ileus (one patient) and temporary, partial small bowel obstruction (one patient). The average amount of radiation administered to the pelvis postoperatively was 5,349 +/- 556 cGy. In one of the eight patients, gastrointestinal symptoms (diarrhea for 24 hours) developed during radiation therapy. Early radiological evaluation confirmed that the small bowel was out of the pelvis in all five of the patients studied. Mesh disruption occurred between 2 and 5 months postoperatively (mean, 3.4 +/- 1.5 months) and was often identified symptomatically by the patient. Seven of the eight survived, with disease remission in six. Pelvic disease was absent at the time of death in the one patient who did not survive. Throughout the follow-up period (mean, 20 months) no survivor has had delayed symptoms of radiation enteritis. In children with pelvic malignancies in whom aggressive application of pelvic irradiation is required, the use of an absorbable pelvic mesh sling appears efficacious in preventing radiation-associated enteritis.
Anatomic Modification

Without SpaceOAR Hydrogel

With SpaceOAR Hydrogel

Prostate

Rectum

Prostate

SpaceOAR

Rectum
Anatomic Modification
Anatomic Modification
Hydrogel Spacer Prospective Multicenter Randomized Controlled Pivotal Trial: Dosimetric and Clinical Effects of Perirectal Spacer Application in Men Undergoing Prostate Image Guided Intensity Modulated Radiation Therapy.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Spacer (n = 148)</th>
<th>Control (n = 71)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>145 (98.0%)</td>
<td>66 (93.0%)</td>
</tr>
<tr>
<td>1</td>
<td>3 (2.0%)</td>
<td>4 (5.6%)</td>
</tr>
<tr>
<td>&gt;2</td>
<td>0 (0.0%)</td>
<td>1 (1.4%)</td>
</tr>
</tbody>
</table>
Rectum separation in patients with cervical cancer for treatment planning in primary chemo-radiation

Simone Mamitz, Volker Budach, Friederike Weißer, Elena Burova, Bernhard Gebauer, Filiberto Guiseppe Vercellino, and Christhardt Kohler

Figure 6a and b: Patient LC. Transversal and sagittal pelvic MRI (T2-FSE) with cervical carcinoma (1) and rectal separation (2).
A Novel Absorbable Radiopaque Hydrogel Spacer to Separate the Head of the Pancreas and Duodenum in Radiation Therapy for Pancreatic Cancer.

The role of radioprotective spacers in clinical practice: a review.

Tang Q¹, Zhao F¹, Yu X¹, Wu L¹, Lu Z¹, Yan S¹.

The characteristics of spacer materials

<table>
<thead>
<tr>
<th>Materials</th>
<th>Cancer sites</th>
<th>Implantation techniques</th>
<th>Biocompatibility</th>
<th>Tolerance</th>
<th>Biodegradability</th>
<th>Stability</th>
<th>Adverse events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic resin (9)</td>
<td>Tongue cancer</td>
<td>Intraceral placement</td>
<td>N</td>
<td>Good</td>
<td>N</td>
<td>++</td>
<td>Rare</td>
</tr>
<tr>
<td>Silicone rubber balloon (7)</td>
<td>Abdominopelvic cancer</td>
<td>Surgical incision</td>
<td>N</td>
<td>Good</td>
<td>N</td>
<td>++</td>
<td>Bowl infection</td>
</tr>
<tr>
<td>Balloon catheters (12)</td>
<td>Cervical carcinoma</td>
<td>Intravaginal placement</td>
<td>N</td>
<td>Good</td>
<td>N</td>
<td>++</td>
<td>Vaginal tear</td>
</tr>
<tr>
<td>HA (13)</td>
<td>Prostate cancer and mediastinal targets</td>
<td>TRUS or CT guided transperineal injection</td>
<td>Y</td>
<td>Excellent</td>
<td>Y</td>
<td>+++</td>
<td>Allergic reaction</td>
</tr>
<tr>
<td>PEG hydrogel (17)</td>
<td>Prostate cancer</td>
<td>TRUS guided transperineal injection</td>
<td>Y</td>
<td>Excellent</td>
<td>Y</td>
<td>+++</td>
<td>Rare</td>
</tr>
<tr>
<td>Collagen (16)</td>
<td>Prostate cancer</td>
<td>TRUS guided transperineal injection</td>
<td>Y</td>
<td>Excellent</td>
<td>Y</td>
<td>+++</td>
<td>High priced</td>
</tr>
<tr>
<td>Biodegradable balloon (15)</td>
<td>Prostate cancer</td>
<td>TRUS guided transperineal injection</td>
<td>Y</td>
<td>Excellent</td>
<td>Y</td>
<td>+++</td>
<td>Rare</td>
</tr>
<tr>
<td>Blood clot (20)</td>
<td>Prostate cancer</td>
<td>TRUS guided transperineal injection</td>
<td>Y</td>
<td>Excellent</td>
<td>Y</td>
<td>+</td>
<td>No</td>
</tr>
<tr>
<td>Acellular human dermis (21)</td>
<td>Liver malignancies</td>
<td>Laparoscopic or open surgery</td>
<td>Y</td>
<td>Good</td>
<td>Y</td>
<td>+++</td>
<td>Surgical infection and postoperative ileus</td>
</tr>
<tr>
<td>Saline-filled spacer (22)</td>
<td>Retropertitoneal sarcoma</td>
<td>Surgery</td>
<td>N</td>
<td>Good</td>
<td>N</td>
<td>+++</td>
<td>No</td>
</tr>
</tbody>
</table>

+, very easy to degradation; ++, easy to degradation; +++, hard to degradation; ++++, very hard to degradation. HA, hyaluronic acid; PEG, polyethylene-glycol; Y, yes; N, no; TRUS, transrectal ultrasound.
Summary

• Anatomic Modification is a simple and powerful tool to improve radiation therapy outcomes

• With increasing utilization of high fraction treatments (SRS, SBRT/SABR, hypofractionation). We will likely see increased utilization of anatomic modification techniques to insure safety and good outcomes

• Don’t neglect the simple and intuitive for the new and expensive.