Learning Objectives

- Understand the difference between diagnostic and therapeutic radiation.
- Know the types of cancer treatments available.
- Compare/contrast external beam therapy and brachytherapy.
- Realize the side effects of radiation therapy and medications available.

There are many techniques used to treat cancer. Surgery can be used to remove cancerous tumors inside or on the body. With chemotherapy, ingested or injected chemicals are used to kill rapidly dividing cells (cancerous and noncancerous). For more information regarding chemotherapy, please access this link. Other cancer treatment methods include immunotherapy, stem cell replacement, hormone therapy, and targeted therapy.

Radiation therapy and Chemotherapy: Two different treatment procedures

Patients diagnosed with cancer might be required to do chemotherapy or radiation therapy. Sometimes, both of these methods are used for a patient. In this picture, a female patient is receiving chemotherapy through an IV. She is participating in cooling therapy while receiving her treatment. By placing her hands and feet in cooling devices, this will lower her chances of losing her finger and toenails. Cold cap therapy is also now available for chemotherapy patients. Wearing this type of device could enable a patient to keep his/her hair during chemotherapy.

Figure \(\PageIndex{1}\): Image used with permission (CC BY 2.0; Jenny Mealing).
Current therapeutic radiation applications involve the use of gamma, x-rays, or protons. Recently, some research facilities are investigating the use of alpha and beta tagged molecules to kill cancer cells. These radioisotopes will first locate a cancer related molecule on a tumor cell. Then, the alpha or beta tagged species will inject its radiation into the tumor. Sr-89 (beta emitter) and Ra-223 (alpha emitter) have been used in clinical research trials of certain types of bone cancers.

Radiation Therapy is used as a treatment to control malignant cells within cancer patients. Oncologists (specialists that deal with cancer) utilize radiation frequently to help slow or cure the spread of cancer within individuals. Radiation is specifically applied to malignant tumors in order to shrink them in size. Medical professionals, mainly radiation oncologists, administer a variety of dosages to patient, contingent to the patients current health, as well as other treatments such as chemotherapy, success of surgery, etc.

External Beam Therapy (Photon and Proton Therapy)

External Beam Therapy (EBT) is a method of delivering a high energy beam of radiation to the precise location of a patient's tumor. These beams can destroy cancer cells and with careful planning, NOT kill surrounding cells. The concept is to have several beams of radiation, each of which is sub-lethal, enter the body from different directions. The only place in the body where the beam would be lethal is at the point where all the beams intersect. Before the EBT process, the patient is three-dimensionally mapped using CT scans and x-rays. The patient receives small tattoos to allow the therapist to line up the beams exactly. Alignment lasers are used to precisely locate the target. The radiation beam is usually generated with a linear accelerator. The video below illustrates the basic preparation and administration of external beam therapy.
Targeting Cancer - Radiation Therapy Treatment Process

Photon EBT utilizes either x-ray or gamma rays. An x-ray source would require a linear accelerator to produce high energy electrons. In contrast, a gamma source incorporates a radioactive isotope (like Co-60). Keep in mind both of these technologies use ionizing radiation. As a result, cancer patients must be monitored throughout their life to ensure they do not develop other cancers, like leukemia. EBT is used to treat the following diseases as well as others:

- Breast cancer
- Colorectal cancer
- Head and neck cancer
- Lung cancer
- Prostate cancer

The majority of radiation patients receive photon EBT. The smaller size of this machine makes this therapy an option for all sizes of hospitals and cancer treatment centers. Photon EBT equipment costs approximately three million dollars. The size and the price of this technology enables smaller facilities to keep their patients closer to home during treatment.

Another method of radiation treatment involving protons is not as commonly used in the United States. This type of therapy requires a cyclotron to generate proton beams (recall, a proton is an ionized H-1 isotope). Unlike x-ray or gamma rays (photon therapy), protons are extremely heavy. Today's proton facilities occupy large plots of land to house (the size of a football field that is three stories high) the medical cyclotron. With a price tag of 150-200 million, these facilities are sporadically located in the United States.
Figure \(\PageIndex{2}\): Current Proton Therapy Centers in the US. The world's first hospital-based proton therapy center was a low energy cyclotron centre for ocular tumours at the Clatterbridge Centre for Oncology in the UK, opened in 1989, followed in 1990 at the Loma Linda University Medical Center in Loma Linda, California. Later, The Northeast Proton Therapy Center at Massachusetts General Hospital was brought online, and the HCL treatment program was transferred to it during 2001 and 2002. By 2010 these facilities were joined by an additional seven regional hospital-based proton therapy centers in the United States alone, and many more worldwide. See Wall Street Journal article for information on the details of opening up a center.

At this time, research facilities are working on miniturizing proton generators. An ideal technology would reduce the cost from hundreds of millions of dollars to about twenty to thirty million per device. This would make proton therapy more available and convenient for patients.

Proton Therapy versus Radiation Therapy

There are many advantages to choosing proton therapy over photon therapy. Unlike photon radiation, proton beams will
only penetrate to the depth of the tumor and not pass through the entire body. This reduces the overall toxicity dose. In addition, fewer treatments are required for proton therapy patients than photon therapy. Unfortunately, proton therapy is more expensive than photon therapy and less common. Once approved by a facility and medical insurance, a patient may have to move temporarily to a larger city to receive treatment. Some forms of cancer have never been clinically treated with proton therapy (namely, breast cancer). Patients desiring proton therapy might not be able to receive type of therapy due to lack of research.

---

**Brachytherapy**

The Greek term brachy means to travel a short distance. This type of radiation involves placing ionizing pellets (seeds) or rods directly at the tumor. Photons (in the form of x-ray or gamma ray) are produced inside the body and will penetrate throughout this particular area localizing the radiation. Pellets are surgically implanted while rods can be temporarily inserted to produce radiation internally. With pellets/seeds, the patient will remain radioactive as long as these devices remain inside the body. People undergoing this type of radiotherapy need to be aware of their constant emission of radiation. Radiation that is administered through rods connected to a photon device will disperse energy immediately and not leave the patient radioactive.

Figure \(\PageIndex{4}\): The picture on the left shows a brachytherapy rod. This device would be connected to a gamma source and connected inside a human body. The second images shows radioactive pellets or seeds that can be surgically implanted near a tumor. Note how small the pellets are when compared to an American penny. Image taken from: [https://c1.staticflickr.com/8/7254/7...74d83b7058.jpg](https://c1.staticflickr.com/8/7254/7...74d83b7058.jpg)

Brachytherapy is widely used in the treatment of cancers involving reproductive organs. Because the radiation is isolated internally, patients are less likely to experience side effects when receiving this type of treatment. Cancers that have been treated with brachytherapy are shown below:

- Prostate
- Breast
- Esophageal
- Lung
- Uterine
- Anal/Rectal
- Sarcomas
- Head and neck
Table 1: Commonly used radiation sources (radionuclides) for brachytherapy.

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Type</th>
<th>Half-life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cesium-131 (\textsuperscript{131}Cs)</td>
<td>Electron Capture, ε</td>
<td>9.7 days</td>
</tr>
<tr>
<td>Cesium-137 (\textsuperscript{137}Cs)</td>
<td>β\textsuperscript{-} particles, γ-rays</td>
<td>30.17 years</td>
</tr>
<tr>
<td>Cobalt-60 (\textsuperscript{60}Co)</td>
<td>β\textsuperscript{-} particles, γ-rays</td>
<td>5.26 years</td>
</tr>
<tr>
<td>Iridium-192 (\textsuperscript{192}Ir)</td>
<td>γ-rays</td>
<td>73.8 days</td>
</tr>
<tr>
<td>Iodine-125 (\textsuperscript{125}I)</td>
<td>Electron Capture, ε</td>
<td>59.6 days</td>
</tr>
<tr>
<td>Palladium-103 (\textsuperscript{103}Pd)</td>
<td>Electron Capture, ε</td>
<td>17.0 days</td>
</tr>
<tr>
<td>Ruthenium-106 (\textsuperscript{106}Ru)</td>
<td>β\textsuperscript{-} particles</td>
<td>1.02 years</td>
</tr>
<tr>
<td>Radium-226 (\textsuperscript{226}Ra)</td>
<td>β\textsuperscript{-} particles</td>
<td>1599 years</td>
</tr>
</tbody>
</table>

**Side Effects of Radiation Therapy**

Patients receiving radiation therapy can experience a variety of side effects. For example, sterility could occur if reproductive organs are irradiated. Skin that has been irradiated can appear dry and feel itchy. Some patients will lose sensation in the irradiated area. Radiation can affect the production of white and red blood cells. A reduction of white blood cells results in immunity disorders. Red blood cell loss causes anemia. Gastrointestinal issues such as diarrhea and nausea are common during radiation therapy. Some patients will lose hair as well. Lastly, dry mouth and tooth decay are prevalent during radiation treatments.

Medications are available to alleviate symptoms of radiation therapy. Narcotics can be prescribed to help alleviate intense pain. Prescription medications like zofran and phenergan can help with nausea. Special mouthwashes have been formulated to reduce dry mouth and cavities.
Zofran is a medication used to prevent nausea and vomiting caused by cancer chemotherapy, radiation therapy, or surgery. A vial of Zofran 4 mg containing ondansetron for intravenous injection. This medicine is a controlled substance and is used for nausea. Images used with permission (left: Public domain; Fvasconcellos and right: CC BY 3.0; Intropin)

Hair loss is a side effect of radiation, but only locally.

Radiation therapy can cause hair loss, but hair is only lost in the area being treated. For instance, radiation to your head may cause you to lose some or all the hair on your head (even eyebrows and lashes), but if you get treatment to your hip, you won’t lose the hair on your head.

References

2. https://weillcornellgucancer.org/201...-cancer-cells/
Contributors

- Paul Flowers (University of North Carolina - Pembroke), Klaus Theopold (University of Delaware) and Richard Langley (Stephen F. Austin State University) with contributing authors. Textbook content produced by OpenStax College is licensed under a Creative Commons Attribution License 4.0 license. Download for free at http://cnx.org/contents/85abf193-2bd...a7ac8df6@9.110).

- CK-12 Foundation by Sharon Bewick, Richard Parsons, Therese Forsythe, Shonna Robinson, and Jean Dupon.

- Emma Gibney (Furman University)