Chapter Five : Radiation Oncology

(Radiotherapy/Radiation therapy)

(It is a medical specialty that is an essential part of a multidisciplinary approach to cancer treatment).

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Radiation therapy as a cancer treatment

Radiation therapy is an effective way to treat cancer and can be used alone or together with other treatments like surgery or chemotherapy (anti-cancer drugs). Using highly precise doses of radiation to damage or destroy cancer cells. Radiation therapy is usually delivered to patients in controlled measures called fractions, over a number of weeks Why?

Because this gives

1) Normal cells time to recover between treatments ,
2) Allows high doses of radiation to be delivered to the cancer site over a period of time.

Radiation therapy is by its very nature a personalized treatment: every patient's treatment is unique and tailored (designed) to suit (fit) where the cancer is situated in the body as well as individual circumstances.

The process of delivering radiation therapy treatments is complex and involves an understanding of medical physics, radiobiology, radiation safety, and the interaction of radiation with other treatments. Each step in the process of radiation therapy requires strict quality control measures to ensure that patients receive the set treatment correctly.

Working in Radiation Oncology

Working in Radiation Oncology also requires excellent communication and teamwork skills.

Daily interactions with patients who may be feeling ill or weak requires the ability to form respectful and trusting relationships with both adult and child patients, and their families, to ensure a joint approach to the patient's treatment

Essential Work Radiation Therapy: Radiation therapy works by damaging the DNA within cancer cells, destroying their ability to reproduce and causing the cells to die.

When the damaged cancer cells are destroyed by radiation, the body naturally eliminates them.

Normal cells can be affected by radiation, but they can repair themselves in a way cancer cells cannot.

Principle of radiation Oncology

What are the career choices in Radiation Oncology?

Radiation Oncology is made up of three unique medical specialties (**Radiation oncologist , Radiation therapist & Radiation oncology medical physicist**) that focus on the treatment of cancer patients with radiation therapy (also known as radiotherapy).

A number of careers in the Radiation Oncology field will lead to professionals working together to treat cancer patients. Qualified experts work together in teams to deliver cancer care through radiation therapy. These professions include:

- **Radiation oncologist** - a medical doctor who completes training to specialise in the management of cancer patients, specifically using radiation therapy. Radiation oncologists use cutting-edge technology and work in teams with other doctors to create and deliver radiation therapy to patients.
- **Radiation therapist** - a health professional who designs, calculates (plans) and provides the radiation dose to patients and is responsible for ongoing patient care and wellbeing of the patient and their family over the length of treatment.
- **Radiation oncology medical physicist** – a scientist who creates, implements and monitors the delivery of radiation therapy, taking into account the protection and safety of patients and others involved in the treatment process.

This team of Radiation Oncology professionals is supported by a larger team which includes: engineers, information technology (IT) support, data managers, oncology nurses, social workers, dieticians and other health professionals.

Other career paths in Radiation Oncology may include ; industry, project management, teaching at University and consulting work, just to name a few.

Safety of Radiation Therapy

New advances in technology and treatment delivery continue to make radiation safe and effective.

A team of medical professionals develop and review the treatment plan for each patient to minimize side effects and assure that the area where the cancer is located is receiving the dose of radiation needed.

The treatment plan and equipment are constantly reviewed to ensure the proper treatment is being given.

Why Use Radiation Therapy?

To cure (treatment) cancer:

- Destroy tumors that have not spread to other body parts.
- Reduce the risk that cancer will return after surgery or chemotherapy.

For palliation (Mitigation) (to reduce symptoms):

- Shrink tumors affecting quality of life, like a lung tumor that is causing shortness of breath.
- Alleviate pain or neurologic symptoms by reducing the size of a tumor.

Team workers of Radiation Oncology

A team of highly trained medical professionals work together to make sure you receive the best possible care while you are undergoing radiation therapy.

Radiation Oncologist

- Oversees the radiation therapy treatments, including working with other members of the radiation therapy team to develop the treatment plan and ensure that each treatment is given safely and accurately.

Medical Radiation Physicist

- Ensures that complex treatment plans are properly tailored for each patient and directs quality control programs for equipment and procedures.

Dosimetrist

- Works with the radiation oncologist and medical physicist to calculate the proper dose of radiation given to the tumor.

Radiation Therapist

- Administers the daily radiation under the radiation oncologist's prescription and supervision.

Radiation Oncology Nurse

- Cares for the patient and family by providing education, emotional support and tips for managing side effects.

Additional Members of the Team

- Social workers, nutritionists, dentists, physical therapists and patient navigators may also assist in a patient's care during their treatment.

Procedures of Radiation Therapy

Radiation therapy can be delivered either externally or internally.

External Radiation Therapy

External beam radiation therapy typically delivers radiation using a linear accelerator.

Internal radiation therapy

Internal radiation therapy, called *brachytherapy*, involves placing radioactive sources into or near the tumor.

External Radiation Therapy

Most patients who receive radiation therapy receive it externally. In this type of treatment, doses of radiation are given to a carefully defined area through a machine that directs the high-energy rays or particles at the cancer and a margin of normal tissue surrounding it. Treatments are usually given once a day, Monday through Friday, over a period of 3 to 7 weeks. Patients normally receive each treatment during an outpatient visit to a hospital or radiation therapy treatment center, and very few require an in-patient admission. Since the radiation is given in relatively small doses, patients who receive external radiation therapy are not considered radioactive and do not need to take any special precautions during the time they are being treated. It is safe for friends, family, and children to be around them.

There are two types of machines that are used to deliver external radiation therapy. One is a linear accelerator, a machine that creates high-energy radiation using electricity to form a stream of fast-moving subatomic particles. The other type of machine contains a radioactive substance, most often cobalt-60, as its source of radiation. These machines deliver the radiation therapy to the tumor with great accuracy, killing the cancer while sparing as much of the surrounding healthy tissue as possible.

Patients who receive external radiation go through a procedure called simulation before treatment starts. This is basically a planning session, where CT scans are taken and the patient's skin is marked to assure that the correct area is treated everyday.

External Radiation Therapy

It is a common cancer treatment that uses high doses of radiation to destroy cancer cells and shrink tumors. A large machine aims radiation at the cancer. The machine moves around the patients without touching them .

1) It doesn't hurt. 2) It doesn't make you radioactive. 3) It can't be seen, felt, or smelled.

The type of equipment used will depend on the location, size and type of cancer.

- **Three-dimensional conformal radiation therapy (3D-CRT)**

A technique where beams of radiation used in treatment are shaped to match the tumor and are delivered accurately from several directions.

- **Intensity modulated radiation therapy (IMRT)**

A form of 3-D CRT in which the physician designates specific doses of radiation that the tumor and normal surrounding tissues receive.

- **Proton Beam Therapy**

A type of radiation therapy that uses high-energy beams (protons) rather than X-rays to treat certain types of cancer.

Most commonly used in the treatment of pediatric, CNS and intraocular cancers.

- **Stereotactic Body Radiotherapy or Stereotactic Radiosurgery**

A specialized form of radiation therapy that focuses high-power energy on a small area of the body. Despite its name, radiosurgery is a treatment, not a surgical procedure.

Radiosurgery generally implies a single high dose or just a few high dose treatments.

Other techniques that enable ultra-precise doses of radiation to tumors include stereotactic radiosurgery, which uses 3-D imaging to determine the exact coordinates of a tumor. The highly focused gamma rays or x-rays then converge on the tumor to treat it. The *Gamma Knife®* is a treatment option that uses radioactive cobalt sources to focus multiple beams of radiation on a small area. Linear accelerators can also be used to deliver stereotactic radiation therapy to the brain. Other parts of the body can be treated as well, and are considered stereotactic body radiation therapy (SBRT). Emerging areas for using SBRT include lung, liver and bone.

Radiation can also be used to cut off blood flow to a tumor in vascular organs like the liver. For instance, *radioembolization* uses microspheres filled with radioactive isotopes to block a tumor's blood supply and starve it.

In addition to being a treatment option for cancer, radiation therapy also is palliative; that is, it can help reduce pain and suffering in patients with advanced cancer. Patients with significant pain, trouble walking or difficulty eating because of a tumor can see an improved quality of life through palliative radiation.

Internal Radiation Therapy

Some situations require radiation to be delivered internally, with or without external beam irradiation. This process is known as brachytherapy, or radiation therapy delivered from a short distance. The decision regarding whether or not to use brachytherapy is related to the type and stage of cancer being treated. This form of radiation is most commonly used for cancers of the uterus, cervix, and prostate, but may also be used for tumors involving the head and neck, breast, lung and thyroid. Brachytherapy is used to deliver radiation doses at levels high enough to control the cancer, while at the same time minimizing exposure to normal tissues. Unlike external beam radiation which delivers radiation to larger areas and in turn exposes larger areas of healthy tissue, the radiation from brachytherapy affects only the tissues that are in close contact to the radioactive source.

There are various brachytherapy methods in which a radioactive material (such as radium, cesium, iridium, iodine, phosphorus, or palladium) is placed directly into or as close to the tumor as possible. The tissues surrounding the radioactive material receive the most radiation, and as you get further away, the radiation received becomes less. The sharp fall-off of radiation dose as distance increases results in less damage to healthy tissues in the area. This method delivers a higher total dose of radiation in a shorter time period. Often, the radioactive substance is "sealed" in small containers (such as seeds, thin wires, or tubes), which are surgically placed or inserted using an "applicator". In other situations, the radioactive substance is "unsealed" and is taken by mouth or injected into the bloodstream.

- Iodine (I-131)

Radioactive iodine (I-131) is commonly used as an unsealed source when treating thyroid cancers. Most patients who receive this form of internal radiation therapy are admitted to the hospital for 3-7 days to minimize exposure to other people. Visitors and healthcare workers must limit the time they spend with the patient, as the patient is radioactive during this treatment. It is best for friends and family to call on the phone rather than visiting in person. Furthermore, great care must be taken in disposing of the patient's waste products, as these, too, are radioactive and can contaminate the public water supply if disposed of incorrectly. The radiation safety department at the hospital takes care of the disposal of all waste and making sure it is safe for the patient to go home and for staff to use the hospital room afterwards by measuring the amount of radiation in the room. Fortunately, the level of radiation decreases rapidly with time, and after a few days, radiation levels are minimal, and patients can return home.

- Implants (Brachytherapy)

Internal radiation therapy (also called brachytherapy) can also take the form of sealed sources, known as *implants* . Sources can be sealed in wires, seeds, capsules, or needles. To precisely deliver the radiation where necessary, a device called an *applicator* may be inserted in the area of the tumor. Applicators are inserted either in an operating room or in the outpatient clinic. The applicator contains no radioactivity, but radioactive material will be placed in the applicator at a later time.

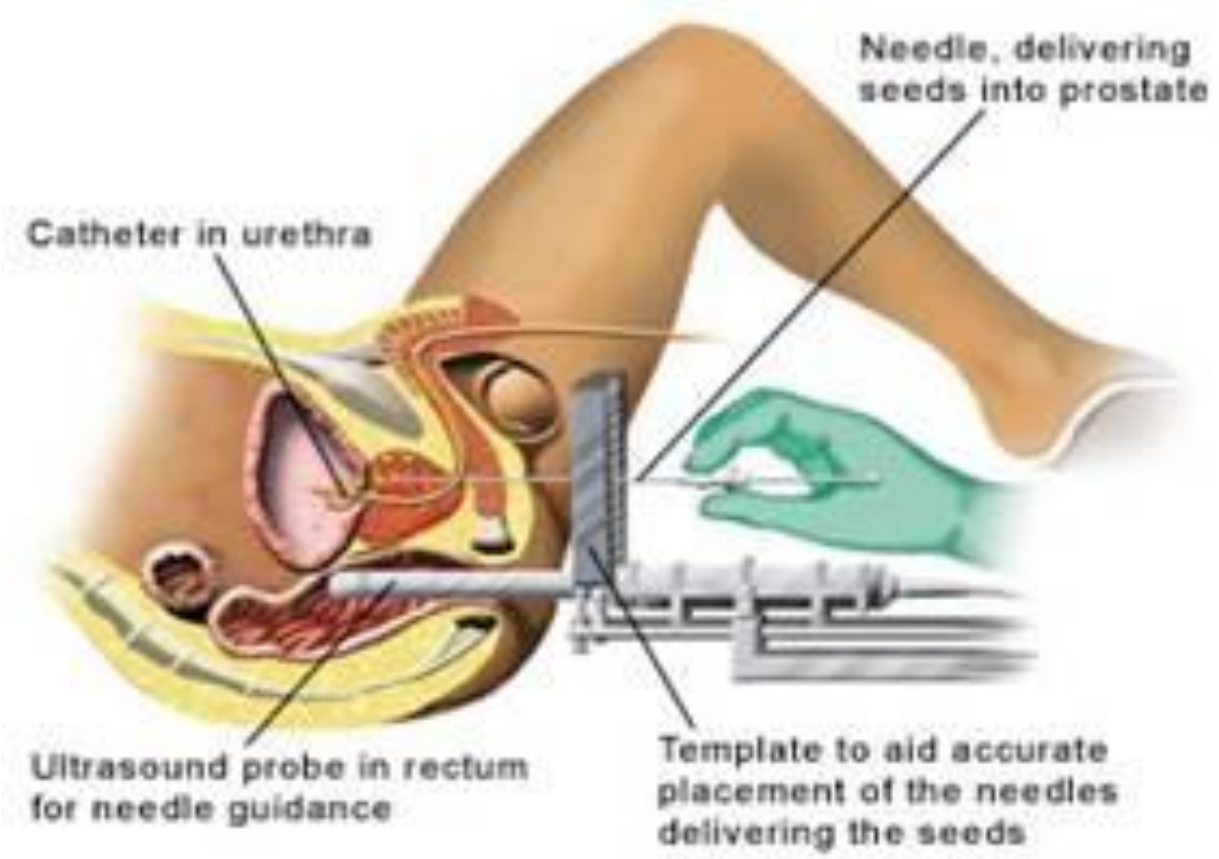
Acute side effects from internal radiation during the treatment are rare, but there could be some discomfort associated with the placement of the applicator. If patients experience significant pain with the applicator, the radiation oncologist can adjust the applicator and/or order medication to relieve the discomfort. If the applicator is placed in the operating room under anesthesia, patients may experience some nausea, weakness, or drowsiness caused by the anesthesia, but these effects do not last long.

Prostate Brachytherapy

Prostate cancer is the most commonly diagnosed malignancy in men. Fortunately, radiation therapy is an effective treatment that can often cure the disease when it is detected at an early stage. If your doctor recommends brachytherapy as the sole modality or in combination with external beam radiation for your prostate cancer, it can be delivered as either low dose rate (LDR) or high dose rate (HDR). HDR treatment for prostate cancer is on the rise; only 4% of men diagnosed with prostate cancer underwent brachytherapy in 1996, whereas an estimated half of all men diagnosed in 2006 are expected to have the treatment.

The procedure

In HDR brachytherapy, the patient is taken to the operating room and plastic catheters are inserted through the perineum (area between the testicles and the anus) and into the prostate while the patient is under anesthesia . An ultrasound probe is inserted into the rectum to visualize the prostate and to make sure the catheters are placed in the proper positions and a Foley catheter is placed to visualize the bladder and drain urine. The treatment catheters and Foley catheter remain in place during the entire treatment time, which usually lasts 2-5 days, and the patient remains in the hospital during this time. A CT scan is then obtained and used by a team of physicists and radiation oncologists to verify the catheter placement and generate the treatment plan (how long the radioactive source will remain in place).


Needle, delivering seeds into prostate
Catheter in urethra
Ultrasound probe in rectum for needle guidance
Template to aid accurate placement of the needles delivering the seeds

Once the plan is finalized, the patient is brought back to the treatment room where the brachytherapy machine is connected to the catheters. The machine automatically pushes the radioactive pellets (often made of Iridium) into each of the catheters and removes them when the application is complete. The amount of time each source stays in a position, known as the *dwell time,*is specifically calculated to ensure adequate dose is delivered to the gland and that normal structures like the urethra receive as little radiation as possible. To prevent exposure to others, no one is allowed in the treatment room while the radioactive source is outside of the machine. You may receive multiple applications over the 2-5 day hospitalization, but after each application, the radioactive sources are removed from your body and you are not radioactive. The length of the treatment course depends on the size and location of the tumor, the dose of radiation prescribed your general health, and other treatments that you have received for your cancer. You will be limited to strict bed rest during this time to prevent movement of the catheters and will be provided with adequate pain mediation to keep you comfortable. After the final application, the catheters are removed. Acute side effects can include pain in the perineum and burning and hesitancy with urination due to the Foley catheter, which can last up to 2 weeks.

Alternatively, low dose rate (LDR) brachytherapy can also be used to treat prostate cancers. Similar to those treated with HDR, patients undergoing LDR are taken to the operating room and placed under anesthesia. A rectal ultrasound is also used to visualize the prostate. Instead of temporary catheters being placed into the prostate, permanent seeds containing radioactive sources are inserted using needles that are removed after the seeds are inserted. The seeds, made of Iodine or Palladium, are permanent implants and cannot be removed once in place. The seed positions are determined either preoperatively or during the procedure itself. The retained seeds slowly emit radiation to the surrounding tissue, over several months, killing the cancer. The patient may stay in the hospital for a day or two to make sure there are no acute side effects. The major difference between HDR and LDR is that you will still be radioactive after the procedure with LDR because the seeds remain in place. This radioactivity slowly decreases over time, known as *radioactive decay* . Although the level of radiation is relatively low, it is recommended that small children avoid sitting on laps of patients and pregnant women stand at least 5 feet away from the patient for at least six months after the treatment. There is also a small risk of the seeds becoming dislodged and moving somewhere else in the body (such as the lungs) or being excreted in semen or urine.

Not all prostate cancers can be treated with brachytherapy. To decide which form of treatment is best for you, discuss all your option with your doctor. No randomized clinical trials have directly compared all the treatment options and shown one modality to be better than another. Acute side effects are generally limited to mild discomfort in the treatment area. Some people experience blood in the urine, stool or semen, or urinary difficulty for a week or two. Long-term side effects may include burning with urination, incontinence of urine or stool, diarrhea, rectal bleeding, and impotence. Always inform your doctor if you experience any of these symptoms.

Vaginal Brachytherapy

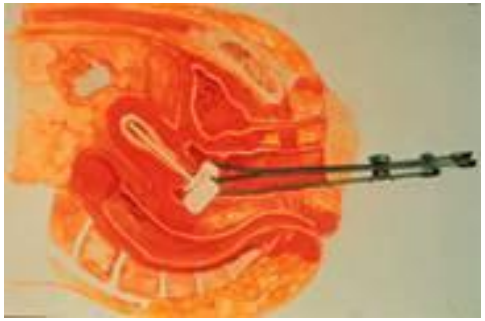
If you are a woman diagnosed with cervical or uterine cancer, your doctor may recommend external beam radiation therapy and/or internal intracavitary radiation treatments. Internal radiation can be delivered as high dose rate (HDR) or low dose rate (LDR) treatments. The radiation can also be delivered with a vaginal cylinder applicator only or with an applicator that treats the cervix and the uterus. You and your doctor will determine which type of radiation and applicator are right for you.

The vaginal cylinder is the simplest form of vaginal brachytherapy. Be sure to let your doctor know if you are having any pain, vaginal discharge, or bleeding. Your doctor will perform a pelvic exam and place small gold seeds into the cervix to allow visualization on x-ray films. A Foley catheter may also be placed in the bladder to allow it to be seen on x-ray as well.

The next step is the insertion of the cylinder. For this, you will be taken into a special lead-lined room, and your doctor will place the cylinder in the vagina, which is an average 1 inch in diameter. The process should not be painful, but you may feel pressure and be slightly uncomfortable. Gauze is inserted in the vagina, around the applicator, to prevent it from moving around. In some cases, contrast (barium) is inserted in the rectum using a small tube. The purpose of the Foley catheter and the rectal contrast are to allow them to be seen on x-ray and to determine how much radiation the bladder and rectum are receiving from the radiation treatment. Once the cylinder is in place, the radiation technician will take x-ray films to verify the position of the cylinder. Depending on the position, some slight adjustments may be needed before proceeding.

Once the physician approves the position, a physicist will generate the radiation treatment plan. The plan takes into account the dose your doctor has prescribed, the activity of the radioactive source, and your anatomy, focusing on limiting the dose to the bladder and rectum. The radioactive source is housed in a special machine known as the HDR or brachytherapy unit, and will be connected to the applicator with a flexible, slender wire. The source travels along this wire into the applicator and rests at each position for a prescribed time, known as the *dwell time* . You will not feel the radioactive source during the treatment, but you may hear the noise of the machine. To prevent radiation exposure to others, no one is allowed in the treatment room while the source is out of the machine, but a video camera and two way microphone will be used to monitor you during the treatment.

If your physician recommends that both the uterus and cervix be treated, an applicator unit known as a tandem and ovoids apparatus may be used. The tandem is a curved rod that is inserted into the uterus, and the ovoids are two small cylinders that flank the cervix. Sometimes, only the tandem or the ovoids will be used, instead of the whole apparatus. Again, your doctor will decide on the best treatment for you. The tandem and ovoids are inserted in the operating room under anesthesia. Proper placement is essential, and to prevent movement of the applicators, gauze packing is inserted in the vaginal vault to secure the applicator.



After the applicator is inserted and your doctor is satisfied with the positioning, x-rays will be taken in the radiation oncology department. As with the vaginal cylinder described above, a Foley catheter and rectal contrast are used to help calculate radiation doses to the bladder and rectum. Your doctor and a physicist generate a prescription and design a treatment plan. For HDR, radiation is delivered similarly to the vaginal cylinder, described above.

After either type of treatment, the source is withdrawn back into the HDR machine, and a physicist will come into the room and verify that there is no radioactivity in your body or outside the machine. The physician will then remove the applicator. The treatment time can last anywhere from 5 to 20 minutes.

- If HDR is not appropriate for you, your doctor may recommend low dose rate or LDR brachytherapy. The insertion of the tandem and ovoids is under anesthesia, similar to the HDR tandem and ovoids. However, you would be admitted to hospital for the entire treatment time. As in the HDR treatment, after the tandem and ovoids are placed, x-ray films will be obtained and your doctor and physicist will generate a treatment plan. The radioactive sources will be placed in the applicator in your hospital room, and you will be radioactive during that time. While the radioactive source is inside of you, visits from friends and family are limited so as not to expose them to radiation. Likewise, the nurses will be limited on how much time they can spend with you. There will be a lead shield in your room that the staff will stand behind to protect themselves from exposure to the radiation.
- The treatment time is usually 2-3 days. You will need to be on strict bed rest so as not to dislodge the applicators. Pain medications will be used to keep you as comfortable as possible. You will have a Foley catheter in to drain urine. At the end of the prescribed treatment, your doctor and physicist will remove the radioactive sources and the applicator.
- How many treatments, what type of brachytherapy, and how often you will need to return all depend on what your doctor recommends. Short-term side effects from these treatments are generally minor, but can include discomfort in the pelvic area, constipation, and burning or hesitancy with urination from the Foley catheter. In the long term, fibrosis (hardening) or shortening of the vaginal canal / tissue may occur, which can cause pain during sexual intercourse or during vaginal exams. Your physician's office will provide you with a vaginal dilator and instructions for its use. Regular use of the dilator will make sexual intercourse and vaginal exams less painful. Your healthcare team can recommend vaginal lubricants or vaginal hormonal therapies to increase natural lubrication. Other long term side effects include chronic diarrhea, blood in the urine or stool, and incontinence of urine or stool. Again, your radiation oncologist should discuss the procedure in detail and answer any questions you might have.

Internal Radiation Therapy (Summary)

I) Radioactive material is placed into tumor or surrounding tissue.

- Also called brachytherapy.
- Radiation sources are placed close to the tumor so large doses can damage the cancer cells.
- Allows minimal radiation exposure to normal tissue.
- Radioactive sources used are thin wires, ribbons, capsules or seeds.
- These can be either permanently or temporarily placed in the body

Permanent vs. Temporary Implants

I) Permanent implants release small amounts of radiation over a period of several months

- Examples include low-dose-rate prostate implants (“seeds”),
- Patients receiving permanent implants may be minimally radioactive and should temporarily avoid close contact with children or pregnant women.

II) Temporary implants are left in the body for several hours to several days

- Patient may require hospitalization during the implant depending on the treatment site ,
- Examples include low-dose-rate gynecologic implants and high-dose-rate prostate or breast implants,

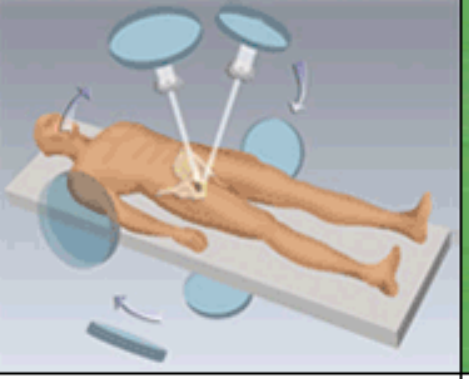


Figure 2:
External Beam Radiotherapy

Figure 3:
Brachytherapy seeds and needles

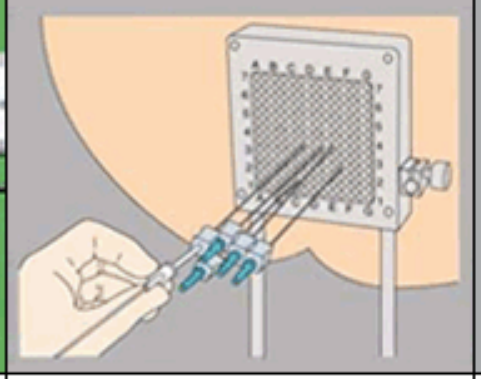


Figure 4: Implanting the seeds
A grid helps guide the needles

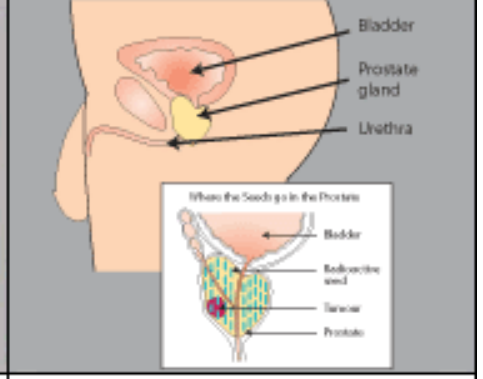
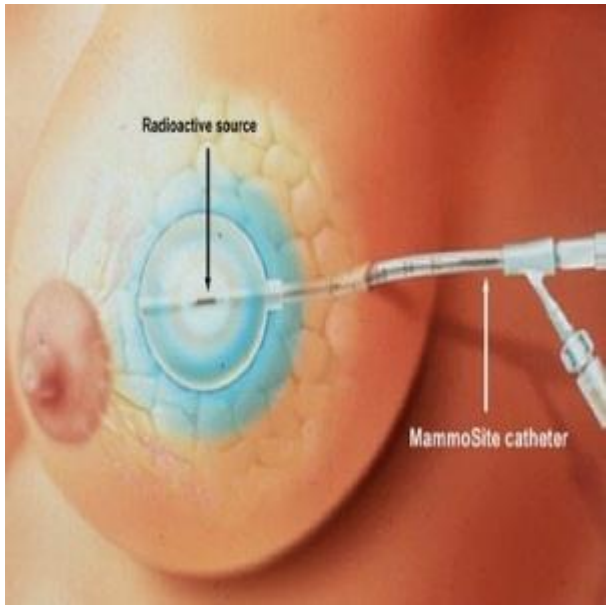


Figure 5:
The seeds in position



Side Effects of Radiation Therapy

Radiation therapy treats many types of cancer effectively. But like other treatments, it often causes side effects. These are different for each person. They depend on the type of cancer, its location, the radiation therapy dose, and your general health.

Why does radiation therapy cause side effects?

High doses of radiation therapy are used to destroy cancer cells. Side effects occur because radiation therapy can also damage healthy cells and tissues near the treatment area. Today, major advances in radiation technology have made it more precise, leading to fewer side effects. For some people, radiation therapy causes few or no side effects. For others, the side effects are more severe.

Reactions often start during the second or third week of treatment. They may last for several weeks after the final treatment.

1) Most side effects begin during the second or third week of treatment. Doctors and nurses may prescribe medications to help with these side effects.

2) Side effects, like skin redness, are generally limited to the area receiving radiation.

3) Fatigue is a common side effect for all cancer patients.

4) Side effects may last for several weeks after the final day of treatment.

Common general side effects

Radiation therapy is a local treatment. Therefore, it only affects the area of the body where the tumor is located. For example, people do not usually lose their hair from having radiation therapy. But if radiation therapy is aimed at a part of the body that grows hair, such as the scalp, a person may have hair loss.

Skin problems. Some people who receive radiation therapy experience dryness, itching, blistering, or peeling. But these side effects often depend on which part of the body received radiation therapy. If you develop skin problem, they usually go away a few weeks after treatment has finished. If skin damage becomes a serious problem, the doctor may change your treatment plan.

Fatigue. Fatigue is feeling tired or exhausted almost all the time. Your level of fatigue depends on whether you are having other treatments, such as chemotherapy.

Long-term side effects. Most side effects go away after treatment. But some continue, come back, or develop later. These late effects may include developing a second cancer. However, the risk of having a second cancer because of radiation therapy is low. This risk is often smaller than the benefit of treating the primary, existing cancer.