

RADIATION THERAPY IN THE MANAGEMENT OF CANCER

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Introduction

Radiotherapy or radiation treatment is defined as the treatment of diseases (mostly malignant) with ionizing radiation. The various types of ionizing radiation are X-rays, gamma rays, electrons; neutrons etc. but rays and high energy X-rays are in common practice. Ionizing radiation are capable of damaging the genetic material (DNA) in vivo without significant deleterious effects on normal tissues. Usually, X-rays are generated from X-ray tube of a Lineal Accelerator and rays from TeleCobalt unit. Radiation can cure or control cancer by inhibiting the cancer cells from dividing or reproducing. About fifty to sixty percent of patients with cancer will require radiation at sometime or other during the course of their disease. Radiation is a safe and effective form of treatment for patients of all ages.

Radiation oncology is relatively a new subject as compared to other medical specialties. However, there is no other medical field which had more speedy evolution than radiation oncology. Within a short span, it has attained tremendous growth and made a place for itself in the medical science showing its utility in the welfare of mankind. Almost a century ago, Famous German physicist, Wilhelm Conrad Roentgen discovered the X-rays on 8th November 1895. Soon after the discovery of X-rays, radioactivity was discovered by Henry Becqerral in 1896 and Radium by Madame Curie in 1898. Radiation was used for treatment of cancer as early as in 1898. Since then, the field of radiation oncology has come a long way. With growing technology and better understanding of radiation biology, radiotherapy achieved many milestones at a faster speed. Since early 1990s, radiation oncology has increasingly become technology oriented. This has resulted in accurate target localization and precise delivery of radiation to the target area resulting into better tumor control, minimal normal tissue complications and to some extent improved survival rates.

BASIC PRINCIPLES OF RADIOTHERAPY

An understanding of the basic principles of radiotherapy is essential to the successful use of radiation therapy. These include:

The higher the dose of the radiation delivered to the tumor, higher the probability of the local control of the tumor. Hence, generally the aim is to deliver the maximum dose to the tumor without causing undue toxicity to the surrounding normal tissues.

The lower the dose to the surrounding normal tissues, the lower the associated morbidity, hence the radiation oncologists use multiple beams, optimized treatment planning, shielding, brachytherapy and other techniques to limit the dose to the surrounding normal tissues, thereby minimizing the morbidity.

Larger tumors require higher doses of radiation for control. Conversely, small or microscopic tumors require lower doses for control.

Hypoxic tumor cells (usually in the center of the tumor) are relatively radioresistant and require higher doses of radiation to achieve cell kill. Surgical removal of the hypoxic cells decreases the radiation dose required and increases the probability of the local control.

The risk of morbidity increases if larger volumes are irradiated. On the other hand, smaller irradiated volumes can tolerate higher radiation doses with less potential morbidity. Hence, the aim is to minimize the volume of tissue irradiated without missing areas harboring the tumor.

Tumor cells usually proliferate faster than the normal tissues. Shortening the time interval between surgery and radiation therapy reduces the repopulation of tumor cells. Hence prolonged delays between surgery and start of radiation therapy should be avoided.

There are basically two types of radiation treatment: **1) External Beam Radiation Therapy (EBRT) and 2) Brachytherapy**. A patient may receive one or the other, or a combination of both

External Beam Radiation Therapy (EBRT) or teletherapy denotes treatment of patient when the source of radiation lies outside the body. The various equipments of EBRT are Linear Accelerator,

Telecoblat Unit, Telecaseim Unit etc. The treatment with EBRT spares the skin (skin sparing effect). Linear accelerator is preferred for the treatment of deep seated tumors like thoracic tumors, pelvic tumors etc. Telecoblat unit is the backbone of any radiotherapy dept. in developing countries like India because it is cost effective and requires low maintenance cost. Modern sophisticated equipments like stereotactic Radiotherapy (X knife) and Stereotactic Radiosurgery (Gamma knife) are expensive machines but very useful in selective patients.

EBRT treatment with conventional fractionation is done once a day with 1.8-2.0 Gy, 5 times a week and lasts for about 5-7 weeks. Majority of the tumors require EBRT doses in the range of 50-70 Gy. It is a painless and noninvasive procedure. Inoperable patients can be treated with reasonably good results. Radiotherapy can be given on emergency basis in certain situations like severe bleeding from cervical cancer, spinal cord compression etc. The irradiated organs are preserved in contrast to the surgical treatment. The treatment can be carried out on OPD basis also but hospitalization may be needed in-between the treatment. Disadvantages of radiotherapy include prolonged treatment and associated toxicity in some patients.

Brachytherapy is the treatment with radioactive material implanted into the tumor bearing area. The various radioactive materials used are Iridium-192, Caesium-137, Iodine-125 and Palladium-103 etc. Currently the brachytherapy treatment is performed with the help of Remote Afterloading Units where there is no risk of radiation exposure to the staff personnel. Brachytherapy has the advantage of delivering high dose of radiation in shorter time simultaneously sparing the surrounding normal structures. The usual treatment with low dose rate (LDR) brachytherapy takes about 3 days and requires one or more fractions. On the other hand HDR brachytherapy treatment is delivered in minutes but multiple fractions (average 3-7 fractions) are required. The tumors where brachytherapy is preferred are cancers of cervix cancer, endometrium, esophagus, head & neck and chest wall tumors.

The goal of radiation therapy can be:

- Curative or radical - Here radiation is used with an intention to eradicate the tumor.
- Palliative, that is, to alleviate or reduce symptoms such as pain, bleeding, respiratory distress etc.
- Adjuvant which is a treatment that is designed to reduce the risk of tumor recurrence. Radiation can be used after surgery for breast cancer in order to reduce the risk of the cancer recurrence.

The radiation oncologist is the medical doctor in charge of a patient's radiation treatment. He or she plans and prescribes the radiation course for the patient. He/she also monitors the patients while they are undergoing treatment. Any side effects/ accompaniments from the radiation treatment are recognized and treated by the radiation oncologist. The other members of the team include the medical physicist, the radiation therapist, and the dosimeterist. Patients may also encounter a registered nurse, dietitian, and social worker, during their course of treatment.

Steps in radiation treatment:

Consultation: At the beginning, the patient is examined by the radiation oncologist for a consultation. During the consultation, the radiation oncologist takes a history and performs a physical examination. He reviews all the pertinent data and all of the investigations that have been performed. He may also request other tests or consultations to be made.

Simulation: The next step is simulation or treatment planning. After the consultation, the radiation oncologist formulates a treatment plan. Here, the patient comes to the radiation department and lies down on a table under a machine, called a simulator. Various immobilization devices may be necessary, such as a head rest or a face mask, in order to make sure the patient is positioned correctly and in the same way for each treatment. There will be various markings that will be made on the skin and various x-rays are taken.

The patients may require more than one session for simulation. Simulation is very important, since it is the step that allows for proper

planning and delivery of the actual treatment. After simulation, there is a lot of behind-the-scenes work. Here the medical physicist is involved. CT scans may have to be taken in order that the computers can calculate and prescribe the dose distribution of the radiation.

Blocks and shields are often fashioned for the patient undergoing radiation treatment. Blocks or shields are pieces of lead that are placed on a tray between the patient and the treatment machine. The blocks basically will cover up normal tissues in the body in order that radiation is delivered principally to the tumor. External radiation is a safe and basically painless form of treatment.

Treatment:

Usually, the treatment course lasts between two and five weeks. Patients are brought by the radiotherapy technologists into the treatment room and positioned onto the treatment table. The radiotherapy technologist then sets up the treatment, and the actual treatment itself takes only a couple of minutes. During the actual treatment, patients are alone in the room but the technologist is outside and can monitor patients through a close circuit television.

The **treatment is painless**. Patients do not hear or feel anything during or after the treatment. Patients then return on schedule to complete the treatment course. During the radiation course, patients are monitored by the radiation oncologist and his/her staff. These are called status checks.

Patients should inform the radiation oncologist of any new symptoms. The side effects/accompaniments of the radiation depend on the exact type of tumor treated and the location of the radiation treatment. During the course of treatment, patients undergo blood tests, sometimes once a week.

Radiation works best when it is given in small doses over several sessions. In this way, it can kill the tumor cells and yet allow sufficient time for the normal healthy cells around the tumor to repair any damage from the radiation.

Brachytherapy is radiation at short distances. The source of radiation is made in the form of wires, seeds or plaques and is inserted

into the tumor for delivering high doses of radiation. These radioactive sources are Cesium, Iridium and Iodine. This type of treatment is very effective in certain types of cancer, such as cancer of the cervix, certain forms of head and neck cancer, and lung cancer.

- Intra-cavity radiation. Here the radioactive sources are placed in a holder and inserted into the body organ, such as the uterus.
- Interstitial therapy. Here rods, ribbons, or wires are directly inserted into the soft tissues of the body and placed right into the tumor for example carcinoma of the tongue.

With these two types of treatment, patients would most likely be admitted to the hospital and have the procedure done during an operation and under anesthesia. Patients would most likely remain in the hospital for several days while the radiation source is in place. In a few instances, the source will be left permanently inside the body. However, in the majority of cases, the radioactive sources will be removed after a few days.

Patients will have restrictions in the number of people visiting and the duration of such visits.

High dose rate brachytherapy. This is another form of radiation therapy that has become very popular in recent years. This is an outpatient form of radiation treatment. The high dose rate machine contains a very high activity radiation source and the source is then delivered through a catheter into a particular organ that is harboring the cancer. Usually the treatment itself lasts only a few minutes. Thereafter, the source is removed and stored within the machine, and the patients go home. Patients may require several sessions of high-dose rate brachytherapy in order to derive the most benefit.

Side effects/Accompaniments:

The extent and the exact type of side effects are determined by the **location of the tumor** and the location of the radiation being delivered. Patients should check with their radiation oncologists in advance so that they are warned of any of these potential side effects.

For instance, patients who are undergoing breast irradiation will typically experience a **redness, dryness or itchiness** of the breasts

that usually begins two to three weeks after the treatment is commenced. It will then continue, but will eventually be cleared several weeks after the radiation treatment course is completed.

Another example of a side effect is diarrhea, nausea or vomiting. This is sometimes experienced by patients undergoing radiation treatment to their abdomens or bowels. In most cases, these side effects, which are called acute, take place during the radiation treatment course and will continue for a few weeks after the course is completed.

In almost all cases, these side effects will go away and patients will be fine. In rare instances, some patients will experience long-term side effects or complications, because the radiation causes damage to an internal organ adjacent to or near the tumor site.

Some of the modern technological advancements are as follows.

1. Linear Accelerator with multileaf collimator.
2. Stereotactic Irradiation
3. Conformal radiotherapy and three dimensional treatment planning
4. Computerised treatment planning
5. CT based simulation
6. Image guided brachytherapy
7. Intraoperative radiotherapy
8. High dose rate (HDR) brachytherapy
9. Pulse dose rate (PDR) brachytherapy
10. Boron neutron capture therapy (BNCT)
11. Online portal imaging
12. Endovascular brachytherapy

Some of the modern technological advancements are discussed below.

3-D (3- dimensional) Radiation Therapy

Patients may also benefit from newer 3-dimensional treatment planning which involves the use of sophisticated software and computers in designing the various treatment beams and using various treatment

blocks in order to precisely localize and focus the radiation to the tumor.

Radio-surgery is a very specialized treatment used for the treatment of various brain tumors and malformations. This is performed with linear accelerators. With radio-surgery, many different fields of radiation are focused on a very small point in the brain,

The effect of radiation can sometimes be enhanced by using radio sensitizer. These are chemicals that can be given during the treatment course. Some commonly used chemotherapy drugs such as Cisplatin and Carboplatin are among radio sensitizers.

Intraoperative radiation is another type of radiation where the patient, while undergoing a surgery, is put under a linear accelerator and a fine beam is being concentrated on the tumor bed. This is mainly helpful in areas which are deep seated and difficult to treat with EBRT due to intervening normal tissues. Initially in the premegavoltage era, IORT was attempted using orthovoltage equipment. The modern use of IORT began in 1960's after the availability of electron beam facility from Linear accelerator. The high energy electron beam employed for IORT is known as IOEBRT. There are few sites which are not accessible with electron applicator e.g. pelvis, chest, skull base etc. These sites are treated by intraoperative brachytherapy (IOHDR). The usual dose of IORT ranges from 10 Gy to 15 Gy. Nag et al have observed encouraging results with IORT in various tumors of head & neck region, pediatric soft tissue sarcomas, colorectal tumors etc. The IORT facility requires dedicated Linear Accelerator and operation theatre and hence has limitations.

In nutshell, radiation therapy is a technology oriented, fast developing specialty. Treatment of cancer with radiotherapy provides effective cure and the palliation of intractable symptoms. In a country like India, where more than 70% patients present in advanced and inoperable stages, radiation therapy plays an important role. With the modern imaging and treatment devices, the tumor extent can be better defined and the treatment can be carried out with more accuracy and precision. However, the available radiotherapy resources in terms of manpower and equipment in our country are far short of the

requirement. Research and training activities also need to be strengthened in the future.

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