



PRINIPLES OF RADIATION THERAPY

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The basis of radiation therapy revolve around the principle that ionizing radiations kill cells

Radiotherapy terminology:

- a. **Radiosensitivity:** refers to susceptibility of the cells or tissue to the killing effect of absorbed radiation.
- b. **Radioresponsive:** Is the degree to which a normal or neoplastic tissue visibility changes during or after radiotherapy.
- c. **Radiocurability:** Is the two-year patient survival after radiotherapy without further progress of the neoplasm and subsequent metastasis.

Mechanism of action of Radiation:

Two theories are postulated

A. Direct or Target theory:

The theory proposes that radiant energy acts by a direct hit on the target molecules with in the cells. To ionize the molecules, either a single or multiple hits are required. During this process energy gets deposited with in the molecule, which is greater than the binding energy of the electrons. This results in ejection of the electrons, a change in the chemical configuration of the molecule and thus damage to the cell. The DNA molecule is the most important target of radiation in the cell, especially linkages and bonds within the DNA molecule.

Depending upon the radiosensitivity of the tissue, dose and duration of radiation is computed and there are three principle effects on the DNA molecule.

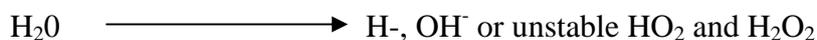
- 1] **Genetic damage-** If damage occurs in germ cells, response is observed in the next generation.
- 2] **Production of cancer-** If the proper dose is not used upto a particular period, there will be derangement of the DNA resulting in abnormal metabolic activity causing production of malignant disease.
- 3] **Cell death-** DNA plays an important role in cell division and is also important for maintaining life of cell. When radiations damage DNA, cell division is interfered. This explains the death of cancer by ionizing radiations. *So radiations can cause cancer or can treat cancer*



B. Indirect theory:

This theory proposes that radiant energy exerts its effects by producing free 'hot' radicals such as peroxides within the cell that damage the specific target.

Water molecule is the major constituent of the cell.

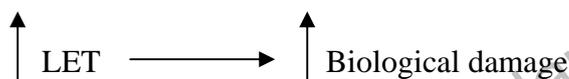


These are highly unstable molecules and react amongst themselves and other solutes within the solution thus producing crucial biological damage to the cell thus causing cell death.

□ Effect on biological tissues:

These are some fundamentals which explain how energy gets absorbed from its source to the tissues and what are the factors which make the tissue more susceptible to this energy.

- **Linear energy transfer (LET)**- It is the measure of the rate at which energy is transferred from ionizing radiation to the exposed tissue.



- **Oxygen effect**- Radiation therapy is more effective in oxygenated cells. These hypoxic cells are radioresistant.
- **Metabolic effects**- Radiosensitivity is directly proportional to the mitotic activity of the cell and indirectly proportional to their level of specialization. This explains that why permanent cells such as neurons, skeletal and cardiac muscles are relatively radioresistant and dividing cells like germ cells, marrow cells, interstitial epithelial cells, lymphoid cells and respiratory cells are more radiosensitive and also the fetus is more sensitive than child or adult.

□ Tissue tolerance to Radiotherapy

Limitations in controlling malignancy or benign neoplasm by radiations is that we have to do it with a minimal normal tissue complications.

Neoplasm radiosensitivity is based on three factors

1] Neoplasm lethal dose- It is that dose of radiation which in vivo produces lethal effects on neoplasm, i.e. 80-90% regression of neoplasm in the treated area.



2] Normal tissue tolerance dose- It is that dose of radiation which normal tissue can absorb without any pathological effects. This varies as per tissue. E.g. 200 rads for the eye lens, 2000 rads per two weeks for kidneys and lungs and 4000 rads per four weeks for the brain.

3] Therapeutic ratio- Normal tissue tolerance dose: neoplasm lethal dose. Neoplasms can be classified into three categories on the basis of therapeutic ratio

- **Sensitive:** When therapeutic ratio is higher e.g. squamous cells carcinoma. These neoplasms require much less dose for treatment than normal tissue tolerance dose. 74% regression is observed after therapy.
- **Moderately sensitive:** The therapeutic ratio is one and regression is about 54%, mast cell neoplasm.
- **Resistant:** Reverse to sensitive e.g. Fibrosarcoma, 34% regression occurs.

Besides these three factors

1. Quantity and quality of radiation.
2. Dose rate of radiation and time factor
3. Volume of the neoplasm to be irradiated should also be considered.

□ **Indications for radiotherapy**

Radiotherapy is indicated in localized solid neoplasms that cannot be excised completely. Usually not indicated if neoplasm has the potential of high incidence of metastasis.

1. When surgery is expected to or has failed.
2. When regional or distant metastasis has not occurred.
3. When radical surgery is unable to remove whole of the neoplasm.
4. When bulk of neoplasm require reduction in size so that can be removed surgically.

□ **DO's before Radiotherapy**

Through clinical examination of the patient, complete blood count, urine analysis, radiograph of the primary site of the neoplasm, radiograph of thorax and abdomen to check evidence of metastasis. Debilitated patient should not be subjected to radiotherapy.

□ **Complication of radiotherapy**

Generally 2 types of complications are observed

Immediate and latent



- ✓ **Immediate complications:** are those, which are observed within minutes or days after irradiation e.g. epilation (hair loss), moist desquamation of skin, skin erythema, chromosome aberration, hematological depression etc.
- ✓ **Latent complications:** When complications are not observable within months or years and occur after a long gap of time. e.g. Leukemia, cancer, life span shortening and lethal genes in coming generations.

Complications also depends upon the area to be irradiated e.g. In case of ophthalmic neoplasm irradiation, the effects can be in form of conjunctivitis, keratitis, cataract etc. These complications are not life threatening but may impair vision

In case of radiotherapy of bone, complications may include fracture, septic osteonecrosis and sarcoma formation.

□ **Methods of Radiotherapy**

A. Teletherapy

The radiation source is kept at a distance from the lesion. It is of four types

1. **Superficial X-Ray Therapy:** It is given through X-ray machine with energy range of 60-100 KeV.
2. **Deep X-ray Therapy:** it is given through X-ray machines with energy range of 200-300 Kev.
3. **Supervoltage Therapy;** It can be provided through
 - I. X-ray machines having linear accelerator (1 Mev to 20 Mev) or Betatron (20 Mev to 100 Mev) or cyclotron.
 - II. Through isotopic X-ray machine with Cobalt or Cesium in a sealed form.
4. **Particulate Beam Therapy:** E, N or P beam can also be used as a mode of teletherapy.

B. Brachytherapy:

It is the therapeutic use of radioisotopes either within the interstitium or on the surface of a neoplasm. Brachytherapy sources are usually in the form of surface applicators, needles, seeds or grains etc. Permanently implanted isotopes are ^{198}Au , ^{222}Rn and ^{125}I . Removable isotopes include ^{192}Ir , ^{60}Co and ^{137}Cs . The methods are

1. **Interstitial Brachytherapy:** When the sources or radiation are within the interstitium of the neoplasm e.g. ^{198}Au , ^{60}Co etc. **Its advantages are**



- ✓ *Continuous low dose irradiation of the neoplasm and high total doses obtained within the neoplasm*
- ✓ *Implantation requires a single anesthetic procedure and hospitalization time is less.*
- ✓ *Normal tissue is least affected.*

And disadvantages are

- ✓ *Implantation is invasive*
 - ✓ *Often a difficult procedure*
 - ✓ *Special training is required.*
2. **Pliesotherapy (Surface brachytherapy):** Use of ^{90}Sr for superficial lesions
 3. **Systemic brachytherapy:** ^{131}I and ^{32}P can be administered systemically.

□ **Choice of Technique**

- a. Small superficial lesions of the skin -----Superficial X ray
- b. Small superficial/ shallow lesion ----- Radium implant, deep therapy or particulate beam therapy.
- c. Deep small lesions ----- Supervoltage or deep therapy.
- d. Shallow or deep, moderate sized lesions ----- Supervoltage or particulate beam therapy.
- e. Substantial lesions- Supervoltage Therapy.