Available Online

Review On Radiation Therapy on Cancer

Mr.Ganesh G.Dhakad ,Ms.Gayatri D.Patil, Ms.Ashwini C.Nikum, Paresh A.patil

Ahinsa Institute Of Pharmacy , Dondaicha 425408

Email::

Abstract

At high doses, radiation therapy kills cancer cells or slows their growth by damaging their DNA. Cancer cells whose DNA is damaged beyond repair stop dividing or die. When the damaged cells die, they are broken down and removed by the body. Radiation therapy does not kill cancer cells right away. It takes days or weeks of treatment before DNA is damaged enough for cancer cells to die. Then, cancer cells keep dying for weeks or months after radiation therapy ends. Radiation therapy is used to treat cancer and ease cancer symptoms. When used to treat cancer, radiation therapy can cure cancer, prevent it from returning, or stop or slow its growth. When treatments are used to ease symptoms, they are known as palliative treatments. External beam radiation may shrink tumors to treat pain and other problems caused by the tumor, such as trouble breathing or loss of bowel and bladder control. Pain from cancer that has spread to the bone can be treated with systemic radiation therapy drugs called radiopharmaceuticals.

Introduction

Radiation therapy or radiotherapy, often abbreviated RT, RTx, or XRT, is a therapy using ionizing radiation, generally provided as part of cancer treatment to control or kill malignant cells and normally delivered by a linear accelerator. Radiation therapy may be curative in a number of types of cancer if they are localized to one area of the body. It may also be used as part of adjuvant therapy, to prevent tumor recurrence after surgery to remove a primary malignant tumor (for example, early stages of breast cancer). Radiation therapy is synergistic with chemotherapy, and has been used before, during, and after chemotherapy in susceptible cancers. The subspecialty of oncology concerned with radiotherapy is called radiation oncology. A physician who practices in this subspecialty is a radiation oncologist.[1]

Radiation therapy is commonly applied to the cancerous tumor because of its ability to

control cell growth. Ionizing radiation works by damaging the DNA of cancerous tissue leading to cellular death. To spare normal tissues (such as skin or organs which radiation must pass through to treat the tumor), shaped radiation beams are aimed from several angles of exposure to intersect at the tumor, providing a much larger absorbed dose there than in the surrounding healthy tissue.[2] Besides the tumour itself, the radiation fields may also include the draining lymph nodes if they are clinically or radiologically involved with the tumor, or if there is thought to be a risk of subclinical malignant spread. It is necessary to include a margin of normal tissue around the tumor to allow for uncertainties in daily set-up and internal tumor motion. These uncertainties can be caused by internal movement (for example, respiration and bladder filling) and movement of external skin marks relative to the tumor position.[3]

Radiation oncology is the medical specialty concerned with prescribing radiation, and is distinct from radiology, the use of radiation in medical imaging and diagnosis. Radiation may be prescribed by a radiation oncologist with intent to cure ("curative") or for adjuvant therapy. It may also be used as palliative treatment (where cure is not possible and the aim is for local disease control or symptomatic relief) or as therapeutic treatment (where the therapy has survival benefit and can be curative). It is also common to combine radiation therapy with surgery, chemotherapy, hormone therapy, immunotherapy or some mixture of the four. Most common cancer types can be treated with radiation therapy in some way.[4]

The precise treatment intent (curative, adjuvant, neoadjuvant therapeutic, or palliative) will depend on the tumor type, location, and stage, as well as the general health of the patient. Total body irradiation (TBI) is a radiation therapy technique used to prepare the body to receive a bone marrow transplant. Brachytherapy, in which a radioactive source is placed inside or next to the area requiring treatment, is another form of radiation therapy that minimizes exposure to healthy tissue during procedures to treat cancers of the breast, prostate and other organs. Radiation therapy has several applications in non-malignant conditions, such as the treatment of trigeminal neuralgia, acoustic neuromas, severe thyroid eye disease, pterygium, pigmented villonodular synovitis, and prevention of keloid scar growth, vascular restenosis, and heterotopic ossification. The use of radiation therapy in non-malignant conditions is limited partly by worries about the risk of radiation-induced cancers.[5]

History of Radiation Therapy

Medicine has used radiation therapy as a treatment for cancer for more than 100 years, with its earliest roots traced from the discovery of X-rays in 1895 by Wilhelm Röntgen. Emil Grubbe of Chicago was possibly the first American physician to use X-rays to treat cancer, beginning in 1896.[6]

The field of radiation therapy began to grow in the early 1900s largely due to the groundbreaking work of Nobel Prize–winning scientist Marie Curie (1867–1934), who discovered the radioactive elements polonium and radium in 1898. This began a new era in medical treatment and research. Through the 1920s the hazards of radiation exposure were not understood, and little protection was used. Radium was believed to have wide curative powers and radiotherapy was applied to many diseases.[7]

Prior to World War 2, the only practical sources of radiation for radiotherapy were radium, its “emanation”, radon gas, and the X-ray tube. External beam radiotherapy (teletherapy) began at the turn of the century with relatively low voltage (<150 kV) X-ray machines. It was found that while superficial tumors could be treated with low voltage X-rays, more penetrating, higher energy beams were required to reach tumors inside the body, requiring higher voltages. Orthovoltage X-rays, which used tube voltages of 200-500 kV, began to be used during the 1920s.[8] To reach the most deeply buried tumors without exposing intervening skin and tissue to dangerous radiation doses required rays with energies of 1 MV or above, called “megavolt” radiation. Producing megavolt X-rays required voltages on the X-ray tube of 3 to 5 million volts, which required huge expensive installations. Megavoltage X-ray units were first built in the late 1930s but because of cost were limited to a few institutions. One of the first, installed at St. Bartholomew’s hospital, London in 1937 and used until 1960, used a 30 foot long X-ray tube and weighed 10 tons. Radium produced megavolt gamma rays, but was extremely rare and expensive due to its low occurrence in ores. In 1937 the entire world supply of radium for radiotherapy was 50 grams, valued at £800,000, or $50 million in 2005 dollars.[9]

The invention of the nuclear reactor in the Manhattan Project during World War 2 made possible the production of artificial radioisotopes for radiotherapy. Cobalt therapy, teletherapy machines using megavolt gamma rays emitted by cobalt-60, a radioisotope produced by irradiating ordinary cobalt metal in a reactor, revolutionized the field between the 1950s and the early 1980s. Cobalt machines were relatively cheap, robust and simple to use, although due to its 5.27 year half-life the cobalt had to be replaced about every 5 years.[10]

Medical linear particle accelerators, developed since the 1940s, began replacing X-ray and cobalt units in the 1980s and these older therapies are now declining. The first medical linear accelerator was used at the Hammersmith Hospital in London in 1953. Linear accelerators can produce higher energies, have more collimated beams, and do not produce radioactive waste with its attendant disposal problems like radioisotope therapies.

With Godfrey Hounsfield’s invention of computed tomography (CT) in 1971, three-dimensional planning became a possibility and created a shift from 2-D to 3-D radiation delivery. CT-based planning allows physicians to more accurately determine the dose distribution using axial tomographic images of the patient’s anatomy. The advent of new imaging technologies, including magnetic resonance imaging (MRI) in the 1970s and positron emission tomography (PET) in the 1980s, has moved radiation therapy from 3-D conformal to intensity-modulated radiation therapy (IMRT) and to image-guided radiation therapy (IGRT) tomotherapy. These advances allowed radiation oncologists to better see and target tumors, which have resulted in better treatment outcomes, more organ preservation and fewer side effects.[11]

While access to radiotherapy is improving globally, more than half of patients in low and middle income countries still do not have available access to the therapy as of 2017.[12]

How Radiation Therapy Works against Cancer

At high doses, radiation therapy kills cancer cells or slows their growth by damaging their DNA. Cancer cells whose DNA is damaged beyond repair stop dividing or die. When the damaged cells die, they are broken down and removed by the body.[13]

Radiation therapy does not kill cancer cells right away. It takes days or weeks of treatment before DNA is damaged enough for cancer cells to die. Then, cancer cells keep dying for weeks or months after radiation therapy ends.

Why People with Cancer Receive Radiation Therapy

Radiation therapy is used to treat cancer and ease cancer symptoms.

When used to treat cancer, radiation therapy can cure cancer, prevent it from returning, or stop or slow its growth. WhenWhen treatments are used to ease symptoms, they are known as palliative treatments. External beam radiation may shrink tumors to treat pain and other problems caused by the tumor, such as trouble breathing or loss of bowel and bladder control. Pain from cancer that has spread to the bone can be treated with systemic radiation therapy drugs called radiopharmaceuticals.[14][15]

Types of Cancer that Are Treated with Radiation Therapy

External beam radiation therapy is used to treat many types of cancer.Brachytherapy is most often used to treat cancers of the head and neck, breast, cervix, prostate, and eye.

A systemic radiation therapy called radioactive iodine, or I-131, is most often used to treat certain types of thyroid cancer. AnotherAnother type of systemic radiation therapy, called targeted radionuclide therapy, is used to treat some patients who have advanced prostate cancer or gastroenteropancreatic neuroendocrine tumor (GEP-NET). This type of treatment may also be referred to as molecular radiotherapy.[16]

How Radiation Is Used with Other Cancer Treatments

For some people, radiation may be the only treatment you need. But, most often, you will have radiation therapy with other cancer treatments, such as surgery, chemotherapy, and immunotherapy. Radiation therapy may be given before, during, or after these other treatments to improve the chances that treatment will work. The timing of when radiation therapy is given depends on the type of cancer being treated and whether the goal of radiation therapy is to treat the cancer or ease symptoms.[17]

When radiation is combined with surgery, it can be given:

Before surgery, to shrink the size of the cancer so it can be removed by surgery and be less likely to return. DuringDuring surgery, so that it goes straight to the cancer without passing through the skin. Radiation therapy used this way is called intraoperative radiation. With this technique, doctors can more easily protect nearby normal tissues from radiation.After surgery to kill any cancer cells that remain.[18]

Medical Use of Radiation Therapy

Different cancers respond to radiation therapy in different ways.

The response of a cancer to radiation is described by its radiosensitivity. Highly radiosensitive cancer cells are rapidly killed by modest doses of radiation. These include leukemias, most lymphomas and germ cell tumors. The majority of epithelial cancers are only moderately radiosensitive, and require a significantly higher dose of radiation (60-70 Gy) to achieve a radical cure.[19] Some types of cancer are notably radioresistant, that is, much higher doses are required to produce a radical cure than may be safe in clinical practice. Renal cell cancer and melanoma are generally considered to be radioresistant but radiation therapy is still a palliative option for many patients with metastatic melanoma. Combining radiation therapy with immunotherapy is an active area of investigation and has shown some promise for melanoma and other cancers.[20]

It is important to distinguish the radiosensitivity of a particular tumor, which to some extent is a laboratory measure, from the radiation “curability” of a cancer in actual clinical practice.

For example, leukemias are not generally curable with radiation therapy, because they are disseminated through the body. Lymphoma may be radically curable if it is localised to one area of the body. Similarly, many of the common, moderately radioresponsive tumors are routinely treated with curative doses of radiation therapy if they are at an early stage. For example, non-melanoma skin cancer, head and neck cancer, breast cancer, non-small cell lung cancer, cervical cancer, anal cancer, and prostate cancer. Metastatic cancers are generally incurable with radiation therapy because it is not possible to treat the whole body.[21]

Before treatment, a CT scan is often performed to identify the tumor and surrounding normal structures. The patient receives small skin marks to guide the placement of treatment fields.Patient positioning is crucial at this stage as the patient will have to be placed in an identical position during each treatment. Many patient positioning devices have been developed for this purpose, including masks and cushions which can be molded to the patient.

The response of a tumor to radiation therapy is also related to its size. Due to complex radiobiology, very large tumors respond less well to radiation than smaller tumors or microscopic disease. Various strategies are used to overcome this effect. The most common technique is surgical resection prior to radiation therapy. This is most commonly seen in the treatment of breast cancer with wide local excision or mastectomy followed by adjuvant radiation therapy. Another method is to shrink the tumor with neoadjuvant chemotherapy prior to radical radiation therapy. A third technique is to enhance the radiosensitivity of the cancer by giving certain drugs during a course of radiation therapy. Examples of radiosensitizing drugs include Cisplatin, Nimorazole, and Cetuximab.[22]

The impact of radiotherapy varies between different types of cancer and different groups. For example, for breast cancer after breast-conserving surgery, radiotherapy has been found to halve the rate at which the disease recurs.[23]

Type's of Radiation Therapy

Historically, the three main divisions of radiation therapy are :

1) External beam radiation therapy (EBRT or XRT) or teletherapy;
2) Brachytherapy or sealed source radiation therapy; and
3) Systemic radioisotope therapy or unsealed source radiotherapy.

The differences relate to the position of the radiation source; external is outside the body, brachytherapy uses sealed radioactive sources placed precisely in the area under treatment, and systemic radioisotopes are given by infusion or oral ingestion. Brachytherapy can use temporary or permanent placement of radioactive sources. The temporary sources are usually placed by a technique called afterloading. In afterloading a hollow tube or applicator is placed surgically in the organ to be treated, and the sources are loaded into the applicator after the applicator is implanted. This minimizes radiation exposure to health care personnel.

Particle therapy is a special case of external beam radiation therapy where the particles are protons or heavier ions.[24]

External beam radiotherapy (EBRT)

is the most common form of radiotherapy (radiation therapy). The patient sits or lies on a couch and an external source of ionizing radiation is pointed at a particular part of the body. In contrast to brachytherapy (sealed source radiotherapy) and unsealed source radiotherapy, in which the radiation source is inside the body, external beam radiotherapy directs the radiation at the tumour from outside the body. Orthovoltage ("superficial") X-rays are used for treating skin cancer and superficial structures. Megavoltage X-rays are used to treat deep-seated tumours (e.g. bladder, bowel, prostate, lung, or brain), whereas megavoltage electron beams are typically used to treat superficial lesions extending to a depth of approximately 5 cm (increasing beam energy corresponds to greater penetration). X-rays and electron beams are by far the most widely used sources for external beam radiotherapy. A small number of centers operate experimental and pilot programs employing beams of heavier particles, particularly protons, owing to the rapid dropoff in absorbed dose beneath the depth of the target.[25]

Brachytherapy

Is a form of radiation therapy where a sealed radiation source is placed inside or next to the area requiring treatment. Brachy is Greek for short. Brachytherapy is commonly used as an effective treatment for cervical, prostate, breast, esophageal and skin cancer and can also be used to treat tumours in many other body sites. Treatment results have demonstrated that the cancer-cure rates of brachytherapy are either comparable to surgery and external beam radiotherapy (EBRT) or are improved when used in combination with these techniques. Brachytherapy can be used alone or in combination with other therapies such as surgery, EBRT and chemotherapy.[26]

Brachytherapy contrasts with unsealed source radiotherapy, in which a therapeutic radionuclide (radioisotope) is injected into the body to chemically localize to the tissue requiring destruction. It also contrasts to External Beam Radiation Therapy (EBRT), in which high-energy x-rays (or occasionally gamma-rays from a radioisotope like cobalt-60) are directed at the tumour from outside the body. Brachytherapy instead involves the precise placement of short-range radiation-sources (radioisotopes, iodine-125 or cesium-131 for instance) directly at the site of the cancerous tumour. These are enclosed in a protective capsule or wire, which allows the ionizing radiation to escape to treat and kill surrounding tissue but prevents the charge of radioisotope from moving or dissolving in body fluids. The capsule may be removed later, or (with some radioisotopes) it may be allowed to remain in place.[27]

A feature of brachytherapy is that the irradiation affects only a very localized area around the radiation sources. Exposure to radiation of healthy tissues farther away from the sources is therefore reduced. In addition, if the patient moves or if there is any movement of the tumour within the body during treatment, the radiation sources retain their correct position in relation to the tumour. These characteristics of brachytherapy provide advantages over EBRT – the tumour can be treated with very high doses of localised radiation whilst reducing the probability of unnecessary damage to surrounding healthy tissues.[28]

A course of brachytherapy can be completed in less time than other radiotherapy techniques. This can help reduce the chance for surviving cancer-cells to divide and grow in the intervals between each radiotherapy dose. Patients typically have to make fewer visits to the radiotherapy clinic compared with EBRT, and may receive the treatment as outpatients. This makes treatment accessible and convenient for many patients. These features of brachytherapy mean that most patients are able to tolerate the brachytherapy procedure very well.

The global market for brachytherapy reached US$680 million in 2013, of which the high-dose rate (HDR) and LDR segments accounted for 70%. Microspheres and electronic brachytherapy comprised the remaining 30%. One analysis predicts that the brachytherapy market may reach over US$2.4 billion in 2030, growing by 8% annually, mainly driven by the microspheres market as well as electronic brachytherapy, which is gaining significant interest worldwide as a user-friendly technology.[29]

Radionuclide therapy

RNT, also known as unsealed source radiotherapy or molecular radiotherapy) uses radioactive substances called radiopharmaceuticals to treat medical conditions, particularly cancer. These are introduced into the body by various means (injection or ingestion are the two most commonplace) and localise to specific locations, organs or tissues depending on their properties and administration routes. This includes anything from a simple compound such as sodium iodide that locates to the thyroid via trapping the iodide ion, to complex biopharmaceuticals such as recombinant antibodies which are attached to radionuclides and seek out specific antigens on cell surfaces.[30]

As such, this is a type of targeted therapy which uses the physical, chemical and biological properties of the radiopharmaceutical to target areas of the body for radiation treatment. The related diagnostic modality of nuclear medicine employs the same principles but uses different types or quantities of radiopharmaceuticals in order to image or analyse functional systems within the patient.

RNT contrasts with sealed-source therapy (brachytherapy) where the radionuclide remains in a capsule or metal wire during treatment and needs to be physically placed precisely at the treatment position.[31]

Side Effects of Radiation Therapy

Radiation therapy is in itself painless. Many low-dose palliative treatments (for example, radiation therapy to bony metastases) cause minimal or no side effects, although short-term pain flare-up can be experienced in the days following treatment due to oedema compressing nerves in the treated area. Higher doses can cause varying side effects during treatment (acute side effects), in the months or years following treatment (long-term side effects), or after re-treatment (cumulative side effects). The nature, severity, and longevity of side effects depends on the organs that receive the radiation, the treatment itself (type of radiation, dose, fractionation, concurrent chemotherapy), and the patient.[32]

Most side effects are predictable and expected. Side effects from radiation are usually limited to the area of the patient's body that is under treatment. Side effects are dose- dependent; for example higher doses of head and neck radiation can be associated with cardiovascular complications, thyroid dysfunction, and pituitary axis dysfunction. Modern radiation therapy aims to reduce side effects to a minimum and to help the patient understand and deal with side effects that are unavoidable.[33]

The main side effects reported are fatigue and skin irritation, like a mild to moderate sun burn. The fatigue often sets in during the middle of a course of treatment and can last for weeks after treatment ends. The irritated skin will heal, but may not be as elastic as it was before.[34]

Acute side effects

Nausea and vomiting

This is not a general side effect of radiation therapy, and mechanistically is associated only with treatment of the stomach or abdomen (which commonly react a few hours after treatment), or with radiation therapy to certain nausea-producing structures in the head during treatment of certain head and neck tumors, most commonly the vestibules of the inner ears.As with any distressing treatment, some patients vomit immediately during radiotherapy, or even in anticipation of it, but this is considered a psychological response. Nausea for any reason can be treated with antiemetics.[35]

Damage to the epithelial surfaces

Epithelial surfaces may sustain damage from radiation therapy. Depending on the area being treated, this may include the skin, oral mucosa, pharyngeal, bowel mucosa and ureter. The rates of onset of damage and recovery from it depend upon the turnover rate of epithelial cells. Typically the skin starts to become pink and sore several weeks into treatment. The reaction may become more severe during the treatment and for up to about one week following the end of radiation therapy, and the skin may break down. Although this moist desquamation is uncomfortable, recovery is usually quick. Skin reactions tend to be worse in areas where there are natural folds in the skin, such as underneath the female breast, behind the ear, and in the groin.[36]

Mouth, throat and stomach sores

If the head and neck area is treated, temporary soreness and ulceration commonly occur in the mouth and throat. If severe, this can affect swallowing, and the patient may need painkillers and nutritional support/food supplements. The esophagus can also become sore if it is treated directly, or if, as commonly occurs, it receives a dose of collateral radiation during treatment of lung cancer. When treating liver malignancies and metastases, it is possible for collateral radiation to cause gastric, stomach or duodenal ulcers. This collateral radiation is commonly caused by non-targeted delivery (reflux) of the radioactive agents being infused. Methods, techniques and devices are available to lower the occurrence of this type of adverse side effect.[37]

Intestinal discomfort

The lower bowel may be treated directly with radiation (treatment of rectal or anal cancer) or be exposed by radiation therapy to other pelvic structures (prostate, bladder, female genital tract). Typical symptoms are soreness, diarrhoea, and nausea. Nutritional interventions may be able to help with diarrhoea associated with radiotherapy. Studies in people having pelvic radiotherapy as part of anticancer treatment for a primary pelvic cancer found that changes in dietary fat, fibre and lactose during radiotherapy reduced diarrhoea at the end of treatment.[38]

Swelling

As part of the general inflammation that occurs, swelling of soft tissues may cause problems during radiation therapy. This is a concern during treatment of brain tumors and brain metastases, especially where there is pre-existing raised intracranial pressure or where the tumor is causing near-total obstruction of a lumen (e.g., trachea or main bronchus). Surgical intervention may be considered prior to treatment with radiation. If surgery is deemed unnecessary or inappropriate, the patient may receive steroids during radiation therapy to reduce swelling.[39]

Infertility

The gonads (ovaries and testicles) are very sensitive to radiation. They may be unable to produce gametes following direct exposure to most normal treatment doses of radiation. Treatment planning for all body sites is designed to minimize, if not completely exclude dose to the gonads if they are not the primary area of treatment.[40]

Late side effects

Late side effects occur months to years after treatment and are generally limited to the area that has been treated. They are often due to damage of blood vessels and connective tissue cells. Many late effects are reduced by fractionating treatment into smaller parts.[41]

Fibrosis

Tissues which have been irradiated tend to become less elastic over time due to a diffuse scarring process.

Epilation

Epilation (hair loss) may occur on any hair bearing skin with doses above 1 Gy. It only occurs within the radiation field/s. Hair loss may be permanent with a single dose of 10 Gy, but if the dose is fractionated permanent hair loss may not occur until dose exceeds 45 Gy.

Dryness

The salivary glands and tear glands have a radiation tolerance of about 30 Gy in 2 Gy fractions, a dose which is exceeded by most radical head and neck cancer treatments. Dry mouth (xerostomia) and dry eyes (xerophthalmia) can become irritating long-term problems and severely reduce the patient’s quality of life. Similarly, sweat glands in treated skin (such as the armpit) tend to stop working, and the naturally moist vaginal mucosa is often dry following pelvic irradiation.[42]

Lymphedema

Lymphedema, a condition of localized fluid retention and tissue swelling, can result from damage to the lymphatic system sustained during radiation therapy. It is the most commonly reported complication in breast radiation therapy patients who receive adjuvant axillary radiotherapy following surgery to clear the axillary lymph nodes.[43]

Cancer

Radiation is a potential cause of cancer, and secondary malignancies are seen in some patients. Cancer survivors are already more likely than the general population to develop malignancies due to a number of factors including lifestyle choices, genetics, and previous radiation treatment. It is difficult to directly quantify the rates of these secondary cancers from any single cause.[44] Studies have found radiation therapy as the cause of secondary malignancies for only a small minority of patients. New techniques such as proton beam therapy and carbon ion radiotherapy which aim to reduce dose to healthy tissues will lower these risks. It starts to occur 4 – 6 years following treatment, although some haematological malignancies may develop within 3 years. In the vast majority of cases, this risk is greatly outweighed by the reduction in risk conferred by treating the primary cancer even in pediatric malignancies which carry a higher burden of secondary malignancies.[45]

Cardiovascular disease

Radiation can increase the risk of heart disease and death as observed in previous breast cancer RT regimens. Therapeutic radiation increases the risk of a subsequent cardiovascular event (i.e., heart attack or stroke) by 1.5 to 4 times a person's normal rate, aggravating factors included.The increase is dose dependent, related to the RT's dose strength, volume and location.[46]

Cardiovascular late side effects have been termed radiation-induced heart disease (RIHD) and radiation-induced vascular disease (RIVD). Symptoms are dose dependent and include cardiomyopathy, myocardial fibrosis, valvular heart disease, coronary artery disease, heart arrhythmia and peripheral artery disease. Radiation-induced fibrosis, vascular cell damage and oxidative stress can lead to these and other late side effect symptoms. Most radiation-induced cardiovascular diseases occur 10 or more years post treatment, making causality determinations more difficult.[47]

Cognitive decline

In cases of radiation applied to the head radiation therapy may cause cognitive decline. Cognitive decline was especially apparent in young children, between the ages of 5 to 11.

Studies found, for example, that the IQ of 5-year-old children declined each year after treatment by several IQ points.[48]

Cumulative side effects

Cumulative effects from this process should not be confused with long-term effects—when short-term effects have disappeared and long-term effects are subclinical, reirradiation can still be problematic.These doses are calculated by the radiation oncologist and many factors are taken into account before the subsequent radiation takes place.[49]

Effects on reproduction

During the first two weeks after fertilization, radiation therapy is lethal but not teratogenic. High doses of radiation during pregnancy induce anomalies, impaired growth and intellectual disability, and there may be an increased risk of childhood leukemia and other tumours in the offspring.[50]

In males previously having undergone radiotherapy, there appears to be no increase in genetic defects or congenital malformations in their children conceived after therapy. However, the use of assisted reproductive technologies and micromanipulation techniques might increase this risk.[51]

Effects on pituitary system

Hypopituitarism commonly develops after radiation therapy for sellar and parasellar neoplasms, extrasellar brain tumours, head and neck tumours, and following whole body irradiation for systemic malignancies. Radiation-induced hypopituitarism mainly affects growth hormone and gonadal hormones.[52] In contrast, adrenocorticotrophic hormone (ACTH) and thyroid stimulating hormone (TSH) deficiencies are the least common among people with radiation-induced hypopituitarism. Changes in prolactin-secretion is usually mild, and vasopressin deficiency appears to be very rare as a consequence of radiation.[53]

Radiation therapy accidents

There are rigorous procedures in place to minimise the risk of accidental overexposure of radiation therapy to patients. However, mistakes do occasionally occur; for example, the radiation therapy machine Therac-25 was responsible for at least six accidents between 1985 and 1987, where patients were given up to one hundred times the intended dose; two people were killed directly by the radiation overdoses. From 2005 to 2010, a hospital in Missouri overexposed 76 patients (most with brain cancer) during a five-year period because new radiation equipment had been set up incorrectly.[54]

Although medical errors are exceptionally rare, radiation oncologists, medical physicists and other members of the radiation therapy treatment team are working to eliminate them. ASTRO has launched a safety initiative called Target Safely that, among other things, aims to record errors nationwide so that doctors can learn from each and every mistake and prevent them from happening. ASTRO also publishes a list of questions for patients to ask their doctors about radiation safety to ensure every treatment is as safe as possible.[55]

Conclusion:-

The advantages of radiation therapy include: death of a large proportion of cancer cells within the entire tumor (there are minimal, if any, cancer cells are left behind in small tumors; thus, radiation alone may be used to cure certain small tumors) Radiation treatment shrinks, slows the growth and, over time, kills cancer cells. One side effect, however, is that healthy tissues in the area that receive radiation also may be destroyed. An important goal during radiation therapy is eating enough to maintain your weight and keep up your strength. Supplementation with low dose irradiation lowered the cancer death rate, reduced infectious diseases, and provided a longer, healthy life in humans. Premature cancer deaths are caused by insufficient radiation.

Reference:-

1) Ellis F. Dose, time and fractionation: a clinical hypothesis. Clin Radiol. 1969;20:1–7. [PubMed] [Google Scholar]
2) International Commission on Radiation Units. Prescribing, recording and reporting photon beam therapy. Supplement to ICRU Report 50. Bethesda: International Commission on Radiation Units and Measurement. MD: ICRU; 1999. [Google Scholar]
3) Feng FY, Kim HM, Lyden TH, Haxer MJ, Feng M, Worden FP, Chepeha DB, Eisbruch A. Intensity-modulated radiotherapy of head and neck cancer aiming to reduce dysphagia: early dose-effect relationships for the swallowing structures. Int J Radiat Oncol Phys. 2007;68:1289–1298. [PubMed] [Google Scholar]
4) Wang-Chesebro A, Xia P, Coleman J, Akazawa C, Roach M 3rd. Intensity-modulated radiotherapy improves lymph node coverage and dose to critical structures compared to with three-dimensional conformal radiation therapy in clinically localized prostate cancer. Int J Radiat Oncol Phys. 2006;66:654–662. [PubMed] [Google Scholar]
5) Mundt AJ, Lujan AE, Rotmensch J, Waggoner SE, Yamada SD, Fleming G, Roeske JC. Intensity-modulated whole pelvic radiotherapy in women with gynecologic malignancies. Int J Radiat Oncol Phys. 2002;52:1330–1337. [PubMed] [Google Scholar]
6) Langen KM, Jones DT. Organ motion and its management. Int J Radiat Oncol Biol Phys. 2001;50:265–278. [PubMed] [Google Scholar]
7) Jaffray DA, Siewerdsen JH, Wong JW, Martinez AA. Flat-panel cone-beam computed tomography for image-guided radiation therapy. Int J Radiat Oncol Biol Phys. 2002;53:1337–1349. [PubMed] [Google Scholar]
8) Gill S, Thomas J, Fox C, Kron T, Rolfo A, Leahy M, Chander S, Williams S, Tai KH, Duchesne GM, Foroudi F. Acute toxicity in prostate cancer patients treated with and without image-guided radiotherapy. Radiat Oncol. 2011;6:145. [PMC free article] [PubMed] [Google Scholar]
9) Duma MN, Kampfer S, Wilkens JJ, Schuster T, Molls M, Geinitz H. Comparative analysis of an image-guided versus a non-image-guided setup approach in terms of delivered dose to the parotid glands in head-and-neck cancer IMRT. Int J Radiat Oncol Biol Phys. 2010;77:1266–1273. [PubMed] [Google Scholar]
10) Barney BM, Lee RJ, Handrahan D, Welsh KT, Cook JT, Sause WT. Image-guided radiotherapy (IGRT) for prostate cancer comparing kV imaging of fiducial markers with cone beam computed tomography (CBCT) Int J Radiat Oncol Biol Phys. 2011;80:301–305. [PubMed] [Google Scholar]
11) Lo SS, Fakiris AJ, Chang EL, Mayr NA, Wang JZ, Papiez L, Teh BS, McGarry RC, Cardenes HR, Timmerman RD. Stereotactic body radiation therapy: a novel treatment modality. Nat Rev Clin Oncol. 2010;7:44–54. [PubMed] [Google Scholar]
12) Tipton K, Launders JH, Inamdar R, Miyamoto C, Schoelles K. Stereotactic body radiation therapy: scope of the literature. Ann Intern Med. 2011;154:737–745. [PubMed] [Google Scholar]
13) Lo SS, Moffatt-Bruce SD, Dawson LA, Schwarz RE, Teh BS, Mayr NA, Lu JJ, Grecula JC, Olencki TE, Timmerman RD. The role of local therapy in the management of lung and liver oligometastases. Nat Rev Clin Oncol. 2011;8:405–416. [PubMed] [Google Scholar]
14) Wu QJ, Wang Z, Yin FF. The impact of respiratory motion and treatment technique on stereotactic body radiation therapy for liver cancer. Med Phys. 2008;35:1440–1451. [PubMed] [Google Scholar]

15) National radiotherapy implementation group report. Stereotactic body radiotherapy; Clinical review of the evidence for SBRT. UK: NRIG; 2010. [Google Scholar]
16) Freeman DE, King CR. Stereotactic body radiotherapy for low-risk prostate cancer: five-year outcomes. Radiat Oncol. 2011;6:3. [PMC free article] [PubMed] [Google Scholar]
17) Laramore GE. Role of particle radiotherapy in the management of head and neck cancer. Current Opin Oncol. 2009;21:224–231. [PubMed] [Google Scholar]
18) Schulz-Ertner D, Tsujii H. Particle radiation therapy using proton and heavier ion beams. J Clin Oncol. 2007;25:953–964. [PubMed] [Google Scholar]
19) Ma CM, Maughan RL. Within the next decade conventional cyclotrons for proton radiotherapy will become obsolete and replaced by far less expensive machines using compact laser systems for the acceleration of the protons. Med Phys. 2006;33:571–573. [PubMed] [Google Scholar]
20) Hall EJ. Cancer caused by x-rays-a random event? Lancet Oncol. 2007;8:369–370. [PubMed] [Google Scholar]
21) Baskar R. Emerging role of radiation induced bystander effects: Cell communications and carcinogenesis. Genome Integr. 2010;1:13. [PMC free article] [PubMed] [Google Scholar]
22) Emami B, Lyman J, Brown A, Coia L, Goitein M, Munzenrider JE, Shank B, Solin LJ, Wesson M. Tolerance of normal tissue to therapeutic irradiation. Int J Radiat Oncol Biol Phys. 1991;21:109–122. [PubMed] [Google Scholar]
23) Verheij M. Clinical biomarkers and imaging for radiotherapy-induced cell death. Cancer Metastasis Rev. 2008;27:471–480. [PubMed] [Google Scholar]
24) Dewey WC, Ling CC, Meyn RE. Radiation-induced apoptosis: relevance to radiotherapy. Int J Radiat Oncol Biol Phys. 1995;33:781–796. [PubMed] [Google Scholar]
25) Rupnow BA, Knox SJ. The role of radiation-induced apoptosis as a determinant of tumor responses to radiation therapy. Apoptosis. 1999;4:115–143. [PubMed] [Google Scholar]
26) Cragg MS, Harris C, Strasser A, Scott CL. Unleashing the power of inhibitors of oncogenic kinases through BH3 mimetics. Nat Rev Cancer. 2009;9:321–326. [PubMed] [Google Scholar]
27) . Jager, P.L.; Que, T.H.; Vaalburg, W.; et al. Carbon-11 choline or FDG-PET for staging of oesophageal cancer? Eur. J. Nucl. Med. 28:1845–9; 2001.
28) Ishiwata, K.; Kasahara, C.; Hatano, K.; et al. Carbon-11 labeled ethionine and propionine as tumor detecting agents. Ann. Nucl. Med. 1:115–22; 1997.
29) Iozzo, P.; Osman, S.; Glaser, M.; et al. In vivo imaging of insulin receptors by PET: Preclinical evaluation of iodine-125 and iodine-124 labelled human insulin. Nucl. Med. Biol. 29:73–82; 2002.
30) Herlin, G.; Persson, B.; Bergstrèom, M.; et al. 11C-harmine as a potential PET tracer for ductal pancreas cancer: In vitro studies. Eur Radiol. 13:729–3; 2003.
31) Brown, W.D.; Oakes, T.R.; DeJesus, O.T.; et al. Fluorine-18- fluoro-L-DOPA dosimetry with carbidopa pretreatment. J. Nucl. Med. 39:1884–91; 1998.
32) Blankenberg, F.G.; Strauss, H.W. Nuclear medicine applications in molecular imaging. J. Magn. Res. Imaging 16:352–61; 2002.
33) Oyama, N.; Akino, H.; Kanamaru, H.; et al. 11C-acetate PET imaging of prostate cancer. J. Nucl. Med. 43:181–6; 2002.
34) Kotzerke, J.; Volkmer, B.G.; Glatting, G.; et al. Intraindividual comparison of [11C]acetate and [11C]choline PET for detection of metastases of prostate cancer. Nuklearmedizin 42:25–30; 2003.
35) 38. Mathews, D.; Oz, O.K. PET in prostate and renal cell carcinoma. Curr. Opin. Urol. 12:381–5; 2002.
36) DeGrado, T.R.; Baldwin, S.W.; Wang, S.; et al. Synthesis and evaluation of (18)F-labeled choline analogs as oncologic PET tracers. J. Nucl. Med. 42:1805–14; 2001

37) Hara, T.; Kosaka, N.; Kishi, H. Development of (18)F-fluoroethylcholine for cancer imaging with PET: Synthesis, biochemistry, and prostate cancer imaging. J. Nucl. Med. 43:187–99; 2002.
38) Hara, T.; Kosaka, N.; Kishi, H. PET imaging of prostate cancer using carbon-11-choline. J. Nucl. Med. 39:990–5; 1998.
39) Sutinen, E.; Nurmi M.; Roivainen A.; et al. Kinetics of [(11)C]choline uptake in prostate cancer: A PET study. Eur. J. Nucl. Med. Mol. Imaging 31:317–24; 2004.
40) Chen, X.; Park, R.; Hou, Y.; et al. MicroPET and autoradiographic imaging of GRP receptor expression with 64Cu-DOTA- [Lys3]bombesin in human prostate adenocarcinoma xenografts. J. Nucl. Med. 45:1390–7; 2004.
41) Rasey, J.S.; Koh, W.J.; Evans, M.L.; et al. Quantifying regional hypoxia in human tumors with positron emission tomography of [18F]fluoromisonidazole: A pretherapy study of 37 patients. Int. J. Radiat. Oncol. Biol. Phys. 36:417–28; 1996.
42) O'Donoghue, J.A.; Zanzonico, P.; Pugachev, A.; et al. Assessment of regional tumor hypoxia using 18F-fluoromisonidazole and 64Cu(II)-diacetyl-bis(N4-methylthiosemicarbazone) positron emission tomography: Comparative study featuring microPET imaging, Po2 probe measurement, autoradiography, and fluorescent microscopy in the R3327-AT and FaDu rat tumor models. Int. J. Radiat. Oncol. Biol. Phys. 61:1493–502; 2005.
43) Piert, M.; Machulla, H.J.; Picchio, M.; et al. Hypoxia-specific tumor imaging with 18F-fluoroazomycin arabinoside. J. Nucl. Med. 46:106–13; 2005.
44) Chao, K.S.; Mutic, S.; Gerber, R.L.; et al. A novel approach to overcome hypoxic tumor resistance: Cu-ATSM-guided intensitymodulated radiation therapy. Int. J. Radiat. Oncol. Biol. Phys. 49:1171–82; 2001.
45) de Jong I.J.; Pruim, J.; Elsinga, P.H.; et al. 11C-choline positron emission tomography for the evaluation after treatment of localized prostate cancer. Eur. Urol. 44:327–8; discussion 38–9; 2003.
46) Ling, C.C.; Humm, J.; Larson, S.; et al. Towards multidimensional radiotherapy (MD-CRT): Biological imaging and biological conformality. Int. J. Radiat. Oncol. Biol. Phys. 47:551–60; 2000.
47) 50. Brahme, A. Individualizing cancer treatment: Biological optimization models in treatment planning and delivery. Int. J. Radiat. Oncol. Biol. Phys. 49:327–37; 2001.
48) Xing, L.; Cotrutz, C.; Hunjan, S.; et al. Inverse planning for functional image-guided IMRT. Phys. Med. Biol. 47:3567–78; 2002. 52. Alber, M.; Paulsen, F.; Eschman, S.M.; et al. On biologically conformal boost dose optimization. Phys. Med. Biol. 48:N31–5; 2003.
49) Yang, Y.; Xing, L. Towards biologically conformal radiation therapy (BCRT): Selective IMRT dose escalation under the guidance of spatial biology distribution. Med. Phys. 32:1473–84; 2005.
50) Seppenwoolde, Y.; Shirato, H.; Kitamura, K.; et al. Precise and real-time measurement of 3D tumor motion in lung due to breathing and heartbeat, measured during radiotherapy. Int. J. Radiat. Oncol. Biol. Phys. 53:822; 2002.
51) Shirato, H.; Seppenwoolde, Y.; Kitamura, K.; et al. Intrafractional tumor motion: Lung and liver. Semin. Radiat. Oncol. 14: 10–8; 2004.
52) Shimizu, S.; Shirato, H.; Ogura, S.; et al. Detection of lung tumor movement in real-time tumor-tracking radiotherapy. Int. J. Radiat. Oncol. Biol. Phys. 51:304–10; 2001.
53) Xu, Q.; Hamilton, R. Novel respiratory gating method based on automated analysis of ultrasonic diaphragm motion. Med. Phys. 32:2124; 2005.
54) Huang, M.H.; Lin, Y.S.; Lee, C.L.; et al. Use of ultrasound to increase effectiveness of isokinetic exercise for knee osteoarthritis. Arch. Phys. Med. Rehabil. 86:1545–51; 2005.

55) Seiler, P.G.; Blattmann, H.; Kirsch S.; et al. A novel tracking technique for the continuous precise measurement of tumour positions in conformal radiotherapy. Phys. Med. Biol. 45:N103– 10; 2000.