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A REVIEW ON RECENT TREATMENT STRATEGIES INRADIATION THERAPY

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ABSTRACT

In recent years remarkable progress has been made towards the understanding of proposed hallmarks of cancer development and treatment however with its increasing incidence, the clinical management of cancer continues to be a challenge for the 21st century treatment modalities comprise of radiation therapy, surgery, chemotherapy, immunotherapy and hormonal therapy. Radiation therapy (RT) is the chief non-surgical method to control malignant tumour. RT has advanced in both methodological and biological aspects over the past few decades. RT remains an important component of cancer treatment with approximate 50% of all cancer patients receiving radiation therapy during their course of illness. it contributes toward 40% of curative treatment for cancer. In radiation therapy uses high energyparticles or waves such as X- rays, Gamma rays, cancer cell. Our cell normally grows and divideto form new cell but cancer cells grow and divide faster than most normal cells. Radiation workby making small breaks in the DNA inside cells. these breaks keep cancer cells from growing and dividing and cause them to die. Nearby normal cell can also be affected by radiation, but most recover and go back to working the way they should. Some of the latest advances in radiotherapy, including 3-D conformal radiotherapy, Intensity modulated radiotherapy and Image-guided radiotherapy help define the target area with high accuracy and effectively deliver precise doses of radiation causing only minimal damage to healthy cells, tissues and organ. This paper present the history and status of RT studies, and principal of radiotherapy. And also we represent the recent treatment strategies of radiation therapy.

Keyword: cancer, radiation therapy, types of mutations, and recent treatments Strategies

1. Introduction

Globally, cancer ranks as the third most common cause of both morbidity and death. Cancer continues to be the biggest cause of mortality worldwide, despite the lack of medications specifically intended for cancer [1]. According to a recent estimate by the International Agency for Research on Cancer (IARC), there are 7.6 million cancer-related deaths globally each year, and 12.7 million new cases are reported. Developing nations bear a disproportionate share of this burden; according to reports, they account for 63% of cancer-related deaths[2,3,4]. Cancer is a disease that is multigenic and multicellular, originating from any sort of cell. and organs whose etiology is complex. Six cancer cell phenotypes, or hallmarks of cancer, have been discovered by Hanahan and Weinberg. These include cells with an infinite capacity for multiplication, proliferation independent of the environment, evasion of apoptosis, angiogenesis, invasion, and metastasis to various body areas. The person will die if they have unchecked cell development or metastatic spread [5]. Over the last ten years, significant advancements have been made in the treatment and understanding of the previously identified hallmarks of cancer. In addition, numerous malignancies are now curable due to advancements in early identification and treatment techniques [6].Protons and a powerful beam of X-rays are used in radiotherapy (RT), sometimes referred to as radiation therapy, a method of cancer treatment. Radiotherapy slows down or completely eradicates the cancer cell. their development.Radiation therapy is administered to

the tumor-affected area or the surgically excised tumor site. Radiation therapy may kill healthy cells in addition to its usual goal of eliminating malignant cells.Chemotherapy is one treatment that can be used in addition to or instead of radiation therapy. Malignant and benign tumors are treated with radiation therapy.[7]

2. HISTORY OF RADIATION THERAPY

Henri Becquerel and Pierre and Marie Curie were the first to describe radioactivity in the late 1890s[8]. The origins of radiotherapy date back approximately 125 years, to the discovery of X-rays in 1895 by W. C. Roentgen, a physicist from Germany. It did not take long for X- rays to be employed in cancer therapies after they were discovered. Just on January 29, 1896, On the advice of physician Ludlam, the E. H. Grubb company, a maker of vacuum tubes, used X- rays for the first time in cancer treatment three days after the discovery of X-rays was announced. Marie Curie established herself as a pioneer in the field of radiation therapy one hundred years ago when she won a second Nobel Prize for her studies on radium. In celebration of a century of advancements, 2011 has been declared the Year of Radiation Therapy in the UK. Since then, radiation therapy has evolved into a recognized medical specialty, and radiation oncology is a field that brings together experts in many scientific and medical fields. Radiation therapy, or radiotherapy, is still used in addition to surgery and chemotherapy. a crucial modality that accounts for only 5% of the overall cost of cancer care and is a very cost- effective single modality treatment. Additionally, radiation therapy is estimated to be administered to 50% of cancer patients during their illness, and it accounts for around 40% of the total amount spent on curative treatment. Advances in radiation treatment equipment (with enhanced X-ray output and treatment delivery), computerized treatment planning systems, imaging techniques, and a better understanding of the radiobiology of radiation therapy are all contributing to the field's rapid advancement [9].

3. PRINCIPAL OF RADIATION THERAPY

RT uses high-intensity radiation to kill cancer cells by introducing energy that ruins the genetic makeup of the cells and prevents them from proliferating. and continue to multiply [10].The energy released by photon beams created by linear accelerators (LINACs) decreases exponentially with depth, with a large energy deposit close to the body's surface. The fact that photon radiation therapy causes oxygen deficiency in solid tumor cells is one of the main drawbacks. Much study has been done on combating hypoxia since tumour cells in a hypoxic environment can be up to 2-3 times more resistant to radiation damage than those in a normal oxygen environment [11].

High-energy radiation deteriorates a cell's genetic material, or DNA (deoxyribonucleic acid), which prevents the cell from dividing and multiplying further. Radiation harms cancerous and healthy cells equally, yet the purpose of radiation therapy aims to minimize exposure to normal cells that are in the radiation's route or next to cancer cells while optimizing the radiation dose to aberrant cancer cells. Compared to cancer cells, normal cells may often heal themselves more quickly and continue to function normally. Differential cancer cell death occurs because cancer cells are generally less effective than normal cells at repairing the damage brought on by radiation therapy.

In addition to being used as a very effective palliative treatment to relieve patients of cancer- related symptoms, radiation therapy can be administered with the goal of curing the patient. Combination approaches with other therapeutic modalities including immunotherapy, chemotherapy, or surgery are further reasons for radiation therapy. If previously utilized the goal of radiation and surgery (neoadjuvant therapy) is to reduce the tumor's size. Radiation therapy, administered as an adjuvant following surgery, will eradicate any microscopic tumor cells that may have remained. It is commonly recognized that different cancers react differently to radiation therapy. A list of frequent malignancies treated with radiation therapy is presente in Table 1.

Radiation therapy can be applied to the cancer site in two different methods. Targeting high- energy rays (photons, protons, or particle radiation) at the tumor's location allows external beam radiation to be applied from outside the body. In the clinical context, this is the most widely used strategy. Brachytherapy, often known as internal radiation, is administered from within the body using radioactive sources that are either seeded directly into the tumor locationor sealed in catheters. Because of its short half-life, this is especially useful for the routine treatment of prostate and gynecological cancers as well as in cases when retreatment is advised[12]

early cancers curable with radiation therapy alone	**cancers curable with radiation therapy in combination with other modalities**
skin cancers (squamous and basel cell)	breast carcinomas
prostate carcinomas	rectal and anal carcinomas
lung carcinomas (non small cell)	local advanced cervix carcinomas
cervix carcinomas	locally advanced head and neck carcinomas
lymphomas(hodgkins and low grade non hodgkins)	locally advanced lung carcinomas
head and neck carcinomas	advanced lymphomas
	bladder carcinomas
	endometrial carcinomas
	cns tumors
	soft tissue sarcomas
	pediatric tumors

table 1. examples of cancer treated with radiation therapy

4. RECENT TREATMENT STRATEGIES IN RADIATION THERAPY

Intensity-modulated radiation therapy (IMRT), image-guided radiation therapy (IGRT), 3- D conformal radiotherapy, stereotactic radiotherapy, brachytherapy, and radioimmunotherapy are currently the most often utilized advanced cancer treatments Intensity modulated radiotherapy

An improved version of three-dimensional conformal radiation therapy is called IMRT. It is especially useful for target volumes near radiosensitive normal tissues that have complicated or concave geometries. In comparison to conformal radiation therapy, it includes two important extra features:

1.Non-uniform intensity of the radiation Beams.

2.Computerized inverse planning

Unlike other radiotherapy procedures, which use uniform radiation intensity, variable radiation intensity is generated across each beam. It is possible to create a very complicated pattern since each beam is divided into hundreds of beamlets, each with a different intensity level (Fig. 1). Several beams can be used to create a highly conformal dose distribution, which enables accurate contouring to a curved target and further normal tissue sparing. The bladder and small bowel, which are located in the center, are protected in (Fig. 2) by the high dose zone, which precisely fits the nodal target volume. A comparative dose-volume histogram (Fig. 3) that displays the volume of bladder irradiation for patients treated with conventional,
conformal, and IMRT plans is used to evaluate the dosimetric advantage. Conformal radiation reduces the volume receiving more than 40 Gy by 20%, while IMRT reduces it by an additional 45%, illustrating the significant dosimetry improvement possible with this approach.[13]

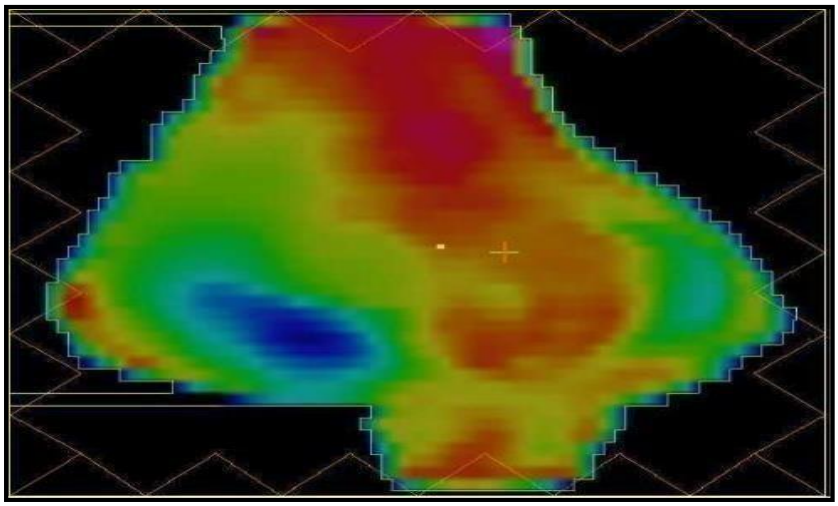


fig. 1: colorized representation of imrt fluence. thefield is split up into a number of beamlets of different intensity.

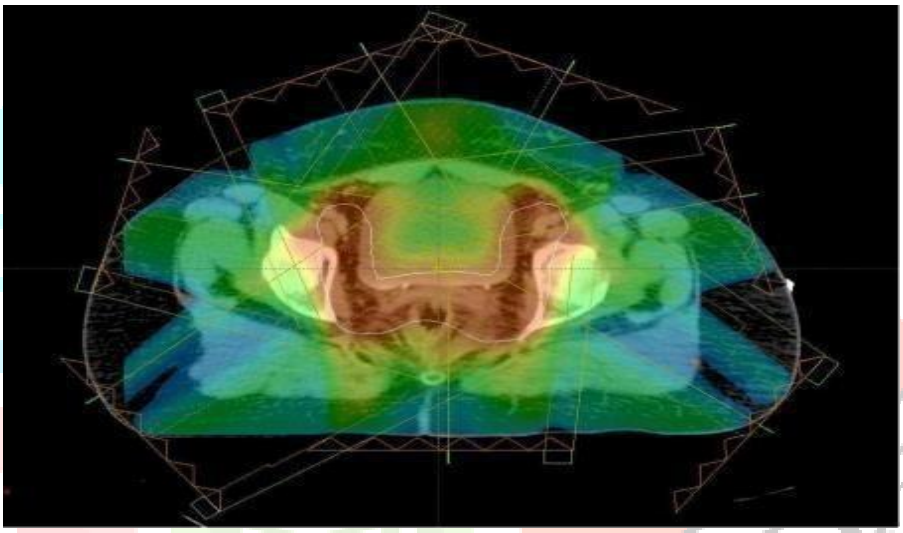


fig. 2: dosage of imrt color-wash. the bladder and bowel doses are decreased when thehigh dose region (red) concavely shapes to the target volume (white)

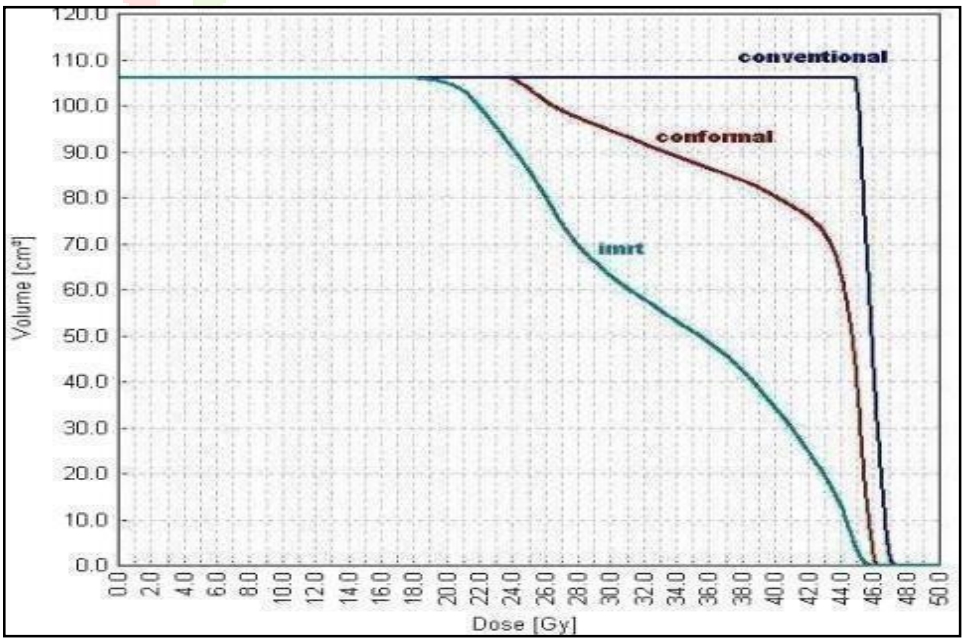


fig.3: comparative dose-volume histogram for the three techniques.

4.1.1 IMRT Planning

Inverse Planning

The first IMRT publication is widely regarded as having been published in 1982 and was written by Brahme et al. from the Karolinska Institute in Stockholm. It offered a rotation therapy beam intensity solution that could provide a consistent dose to a target with a donut shape. The problem was phrased as a "inverse" problem, meaning that the desired dosage distribution was first established, and an integral equation was then solved to determine the dose, in contrast to the previous standard so-called "forward" approaches, where the beam intensity is first determined and then the dose is computed. To supply it, determine the suitable beam intensity. These days, we call this procedure "inverse" planning. Brahme proposed a deconvolution approach, which first "deconvolved" the desired dose distribution in the patient into a point-spread dose kernel and point irradiation distributions, and then back projected the point irradiation distributions into fluence profiles, as a general solution for determining the best incident beam fluence distributions to provide the desired dose distribution to the target volume. Though this approach has not been employed therapeutically, the projection and back- projection processes have some conceptual problems in that they could produce negative fluences, necessitating some kind of reduction to zero.

4.1.2 IMRT Delivery Techniques

Metal compensators were unable to provide IMRT with the newly created inverse planning in an efficient manner; hence, multileaf collimators (MLCs), which were essentially launched forIt was discovered that field shaping was the ideal tool for this task. As seen in (Fig.4), MLCs are made up of pairs of highly absorbing tungsten leaves that can move against one another on opposite sides of the treatment fields and block incident radiation to create irregular fields that resemble the target tumor in shape. MLCs are motor-driven, computer-controlled devices that have the ability to modulate intensity. The two main modes of operation for MLCs are step- shoot and dynamic.

Webb was the first to formulate the IMRT inverse problem as an optimization problem. issue that reduces a target or "cost" function. Since the inverse problem cannot be solved exactly, IMRT planning involves making trade-offs between dose savings to adjacent organs and target coverage. This idea has evolved into the foundational idea of IMRT planning. Fast gradient descent methods can be utilized to determine the solution to the problem expressed as a quadratic objective function because Bortfeld et al. discovered that IMRT planning is essentially the reverse of CT reconstruction. A few years later, in 1995, the first MLC-based IMRT of a patient with prostate cancer was performed using this technique in the planning environment of Memorial Sloan Kettering Cancer Center (MSKCC).

But in the end, it wasdosage-volume limitations were implemented in order to achieve further improvements after it was realized that optimization based on basic dose targets and restrictions, such as minimum and maximum doses, did not produce sufficient results. Nowadays, the majority of commercial inverse planning systems require dose-volume-based targets and/or limitations. Furthermore, optimization of IMRT according to biological aims and limits has been proposed. Effective uniform dose (EUD)-based inverse planning is another optimization strategy that falls between pure physical dosage objectives (or restrictions) and biological planning objectives. The equivalent of a non-uniform dose distribution (EuD) is the dose that, when administered uniformly to an organ or structure, produces the same biological or clinical result [14].

fig. 4: multileaf collimators (mlcs)

Dynamic IMRT

During the therapy delivery process, the dynamic method maintains the desired intensity modulation by having the beam on while the MLC leaves move. beginning with a certain field opening and progressing by limiting or Because of MLC leaves, the different intensity maps allow for the creation of any field shape. A wedge-shaped field can be created, mostly, by keeping one leaf immobile and moving the other leaf in its direction. Convery and Rosenbloom provided a brilliant concept for the arrangement of MLC movement, which is still utilized in clinical IMRT therapy today.

They suggested that a unidirectional sweep motion of MLC leaves could be used to create a modulated intensity profile, in which the beam's intensity at any given location x is proportional to the difference between the timings tB(x) and tA(x). where tA(x) is the end time when leaf A passes through the same point as leaf B, and tB(x) is the time when leaf B crosses the point x and begins the irradiation process. (Fig. 5) illustrates the entire idea of stopping the radiation process at point x. It was difficult to construct a suitable leaf trajectory since the treatment delivery time that yields the necessary intensity, tB(x) – tA(x), depends on the leaf trajectory. Convery and Rosenbloom also used normal linear programming to numerically optimize the approach for the leaf trajectory, aiming for the lowest treatment time while imposing some leaf speed restrictions.

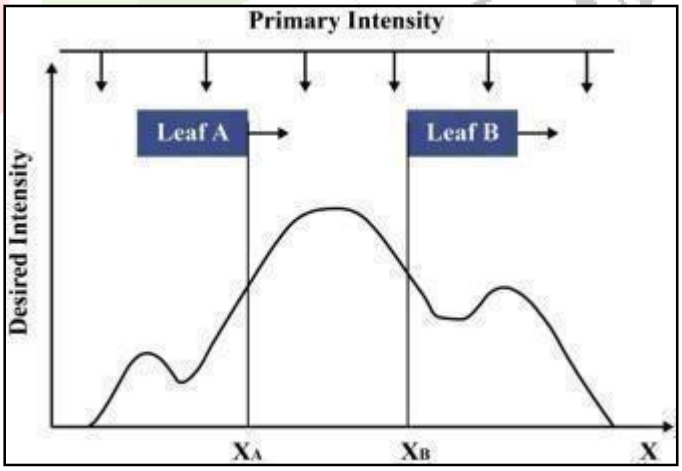


fig. 5: one leaf pair is used to generate a one-dimensional intensity-modulation.

Stein et al., Sevensson et al., and Spirou and Chui all made simultaneous and separate modifications to Convery and Rosenbloom's work. They demonstrated how Convery and Rosenbloom's leaf trajectory problem can be resolved if the trailingThe leading leaf B creates the reduction in the beam profile, whereas leaf A molds the increase.The formula they arrived at is as follows.

$$v(x) = \frac{Vmax}{1-Vmax(dl/dx)}$$

Step and shoot IMRT

Step and shoot, sometimes known as stop and shoot, is a multiple static field approach where the patient is treated in many fields, each of which is subdivided into smaller fields. The beam is deflected while the MLC departs to take up the next position in these subfields, which are delivered in numerous distinct steps, in a particular order, and only one at a time. Step and shoot approach was utilized in 1991 by Art Boyer and associates from the MD Anderson Cancer Center in Houston to deliver IMRT usingeach segment's minimal number of monitor units (MU).

To limit leakage radiation, Art Boyer and Bortfeld et al. devised a leaf sequencing algorithm for step and shoot IMRT in 1993. The method's goal was to achieve the smallest number of MUs. (Fig. 6) provides an illustration of the procedure. By moving the leaf pair at several static places and superimposing subfields from the series of discrete left and right leave settings, one can achieve the one-dimensional modulated intensity. Boyer and Bortfeld state that a leaf pair will always move in a single direction when the first up-step is paired with the first down-step and the second up-step is paired with the second down-step. This approach is known as the "leaf sweep" technique and is mostly utilized in IMRT. delivery. The "close in" technique, in which leaves move in both directions to close in on the peaks, is an alternative to leaf sweeping. Using nine gantry angles, Bortfelset al. performed inverse planning to a polystyrene slab phantom for prostate therapy; 225 segments were produced by his generated step-shoot sweep leaf approach, which was used to make the MLC segments. To verify the dose, the film was inserted on a phantom. It took about three hours to complete the first MLC-based IMRT treatment on a phantom utilizing the frequently used, contemporary dosage verification technique [15].

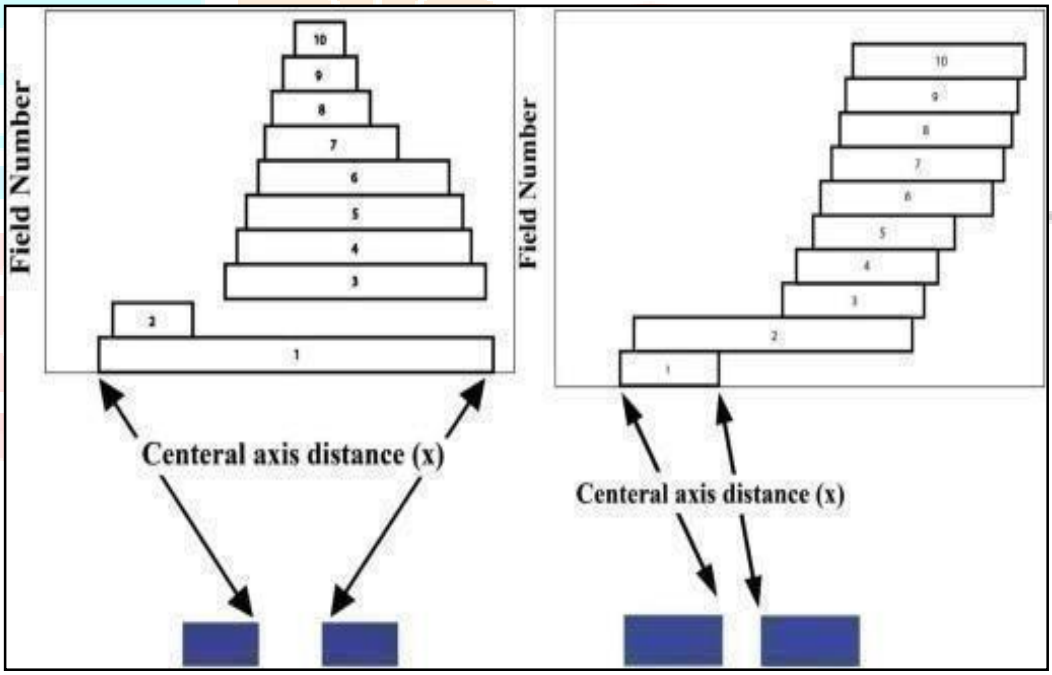


fig. 6:"close-in" leaf setting technique; "leaf-sweep" leaf setting technique

4.1.3 Clinical Experience of IMRT

IMRT is a relatively new field of study that is expanding quickly. There are lots of them. published reports of comparative planning studies showing that IMRT can produce superior dose distribution for a variety of tumor sites, such as head and neck, gynecological, prostate, breast, glioma, and medulloblastoma. Nevertheless, there are currently relatively few clinical trials that show the expected clinical effect, and no prospective randomized clinical trials have been published as of yet.

Head and Neck Cancer

For head and neck malignancies, radiotherapy treatment is often linked to long-term morbidity. Due to the target volume's intricacy and concavity as well as the close vicinity of radiosensitive dose-limiting features, these tumors offer a great deal of potential for benefiting from IMRT. Improved target dosages and preservation of the normal tissues have been shown in a number of recent investigations. parotid-sparing IMRT was utilized for the first time at Michigan University. Compared to glands treated with normal doses, which only recovered to a level of 3%, the parotid glands that were spared underwent a 63% recovery. A evaluation of 126 patients who had IMRT revealed satisfactory local control and no rise in recurrence in the area around the parotid glands that were spared.

Prostate Cancer

In prostate cancer, a dosage response connection has been seen. The advent of conformal radiation made dose escalation possible, and other organizations have utilized IMRT to raise the dose even further. Although there has been little information released about acute and late toxicity, it is still too early to determine survival rates. Apart from increasing the dosage, pelvic nodal irradiation combined with a boost to the main tumoris now achievable with IMRT as a single-phase therapy.

Breast cancer

Breast cancer patients who receive post-operative radiation therapy benefit greatly in terms of local control and survival; nevertheless, long-term follow-up studies have revealed an increase in side effects, such as discomfort, rib fractures, heart illness, and lung damage. By making up for missing tissue, IMRT can increase dose uniformity and, as a result, enhance the cosmetic result. IMRT can increase the tumor bed; this matter will be investigated in a UK randomised trial of partial breast irradiation [16].

4.2 Conformal Radiotherapy

The accuracy of identifying the tumor and the organs at danger was significantly increased with the introduction of CT scanning. A rebuilt three-dimensional target volume is produced by identifying and drawing the tumor onto each cross-sectional image (Fig. 7). The After that,radiation beams are formed to fit this volume and shield the healthy tissues. Although this method improves the dose's geographical distribution, it is still impossible to omit normal tissues that are encircled by a tumor (Fig. 8).

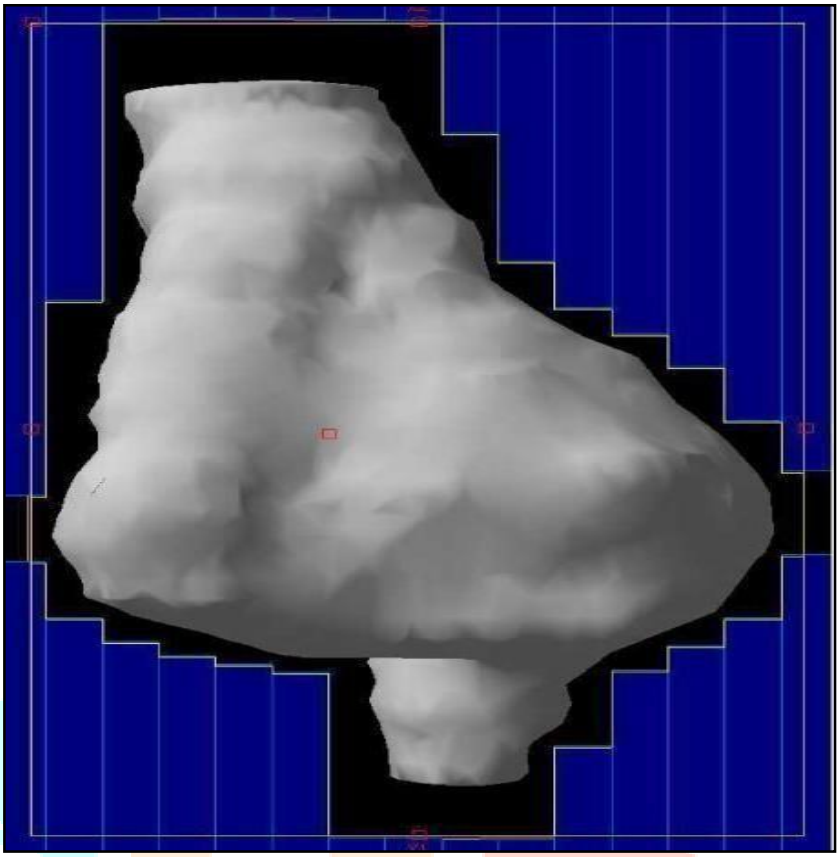


fig 7: field that conforms. every ct slice has the volume indicated, and a three-dimensionalvolume is produced (white). mlc leaves are used to shape fields (blue).

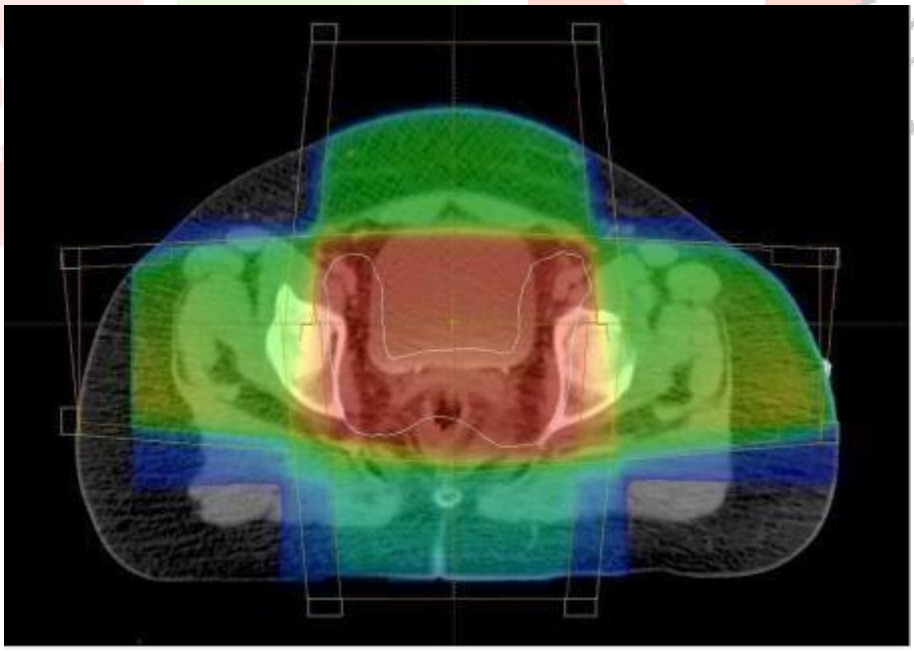


fig. 8: compliant dosage color-washing. the white contour represents the goal volume. part of the bladder is located in the brick-shaped high dosage zone (red).

Nowadays, many tumor locations, including those of the head and neck, brain, lung, prostate, and bladder, are routinely treated using conformal radiation therapy. The anticipated decrease in toxicity as a result of the enhanced conformance has been validated through clinical research. Patients with prostate cancer were randomly assigned to receive conformal or conventional radiation by Dearnaley et al. In the conformal arm, long-term rectal toxicity dropped from 15% to just 5%. The use of increasing doses to treat prostate cancer has been made possible by this decrease in morbidity. The recommended dose was raised by Memorial

Sloane Kettering Hospital researchers from 64 to 81 Gy, which enhanced tumor control but increased toxicity risk. It is essential to further minimize the volume of rectum irradiated in order to treat with these high doses. The implementation of IMRT would be necessary for this to happen. [17]

4.3 Image Guided Radiation Therapy

Medical imaging is used in image-guided radiation therapy (IGRT) to help deliver precise and accurate radiation treatment.A linear accelerator is used by IGRT, orUse a synchrotron or cyclotron to create and administer radiation treatment. Before or during treatment, these devices might also be equipped with imaging technologies to scan the tumor. After comparing these scans to the simulated reference images, your doctor and radiation therapists will make
any necessary adjustments. Your doctor and treatment team will be able to more precisely target the cancer with radiation while avoiding healthy tissue by modifying both your posture and the radiation beams.Your tumor may be scanned by IGRT using computed tomography (CT), magnetic resonance imaging (MRI), ultrasound (US), or x-ray.
When treating tumors in movable organs like the liver, pancreas, prostate gland, or lungs, IGRT uses adaptive approaches with high soft tissue resolution imaging, 4D gating, or fiducials. Tumors close to vital organs and tissues are also treated by it. Doctors could employ IGRT. involves stereotactic radiosurgery, proton beam therapy, intensity-modulated radiation therapy (IMRT), or stereotactic body radiotherapy (SBRT). These sophisticated types of high- precision radiotherapy provide precise radiation dosages to a tumor or particular regions inside it by using computers to operate x-ray accelerators.The key to lowering and eventually eliminating the uncertainties is image-guided radiation therapy (IGRT), which makes use of cutting-edge imaging technologies to more precisely pinpoint the tumor target [18].

4.3.1 Definition of IGRT

The term "IGRT" has no accepted or recognized definition. It has been quite mutable and author-dependent, with varying interpretations. Some define it extremely broadly, including the following: using imaging to diagnose and detect conditions; defining target volumes and organs-at-risk (OARs); identifying biological characteristics; designing dose distribution; ensuring and verifying dose delivery; and interpreting treatmentreply.Rather than IGRT, this is more appropriately called image-based radiation therapy. "Use of frequent imaging within the radiation treatment room, with decisions based on imaging to improve precision of radiation therapy delivery"—that is, "the process of in-room imaging guiding radiation delivery"—is a more precise and widely recognized definition of IGRT. Planar imaging, cine-imaging, volumetric imaging, surface-matching, surface-tracking, marker localization, and marker tracking are some examples of imaging techniques. Stereotactic radiosurgery/radiotherapy (SRS/SRT), IMRT, and 3D-CRT are possible treatment delivery modalities in IGRT [19].

4.3.2 The Concept of IGRT

Surgical procedures, notwithstanding their technical complexity, allow operating surgeons to directly observe and manage their targets, removing any uncertainty regarding identification and appropriate management. Even though radiotherapy is a local treatment that tries to accomplish comparable aims, has the inherent drawback of requiring a great deal of assumption when employing conventional treatment methods. This model is used for plan formulation and
dosage computation. The 3D image dataset obtained during simulation is a snapshot of the tumor, its relationship to normal structures, and the shape and position of the patient at a particular time point. Many assumptions are made regarding clinical target volume (CTV) margins, which define the microscopic spread surrounding the tumor, and planning target volume (PTV) margins, which take into account setup errors and the expected range of internal organ motion, during the planning stage. These assumptions are based on previous experience and literature. Then, the procedure is performed under the premise that all of those presumptions would be true. the first being that the patient's and the tumor's anatomy, as well as their positions in relation to the positioning devices, have not altered since the simulation. This is true for any given patient during regular treatment sessions. Nonetheless, it is blatantly incorrect to assume that the dosage determined using the CT dataset on the planning system corresponds to the dose administered during each portion or the full course of radiation therapy. In addition, planning radiotherapy on a static image collection is unable to account for inaccuracies resulting from the motion of the targets and internal organs

during respiration and peristalsis. Wider PTV margins are taken to guarantee that none of these assumptions will
impair the dosage distribution to the CTV. This results in a high volume of typicaltissues that will be exposed to radiation. IGRT provides a way to take regular "snapshots" of this data over the course of treatment, allowing for the precise and exact delivery of radiation. Simply put, the IGRT procedure makes sure that, while limiting "collateral damage," the administered treatment precisely targets the tumor and matches the desired treatment. Using the proper localization devices and PTV margins can help reduce changes to the composite administered dose and their effects on toxicity and disease control. Occasionally, if significant deviations beyond predefined limits are noticed, replanning can be necessary.

IGRT makes it possible to evaluate the "patient model's" geometric accuracy while receiving therapy. It offers a way in which anatomical variations frominitial plan are established, and dosimetric assumptions are updated using these data. Daily repositioning to record the patient's position in line with the base plan or real-time recalculation of treatment delivery to account for the patient's presentation during a certain fraction are two examples of correction strategies. Adaptive radiotherapy refers to this concept of periodically reviewing treatment and taking into consideration the variations between the actual anatomy of the patient on any given day and the treatment plan snapshot. To maintain therapy on course with the desired course of action, the ultimate objective is to reassess and, in certain cases, modify daily posture. Dose titration to maximize efficacy or minimize negative effects could be one of the future uses.

4.3.3 IGRT Technology Solutions

Based on the imaging techniques employed, the IGRTSystems can be roughly classified as either radiation-based or non-radiation-based.

A. Non-Radiation Based System

These could make use of MRI equipment integrated into the treatment room, electromagnetic tracking, ultrasound, and camera-based systems.

A1. Ultrasound-Based System

These systems (SonArray, Clarity, BAT, etc.) gather three-dimensional images that aid in target alignment and interfractional error correction. With a 3-5 mm geometric accuracy, the main benefit is that there is no ionizing radiation. Radiotherapy is frequently applied on the breast, lung, and prostate.

A2. Camera-Based(Infrared) or Optical Tracking System

In order to help in the computation of treatment couch translation and the alignment of the treatment isocenter with the plan isocenter, these methods identify the patient reference setup point positions relative to their location in the planning CT coordinate system. Uses for optical tracking include intrafraction position monitoring for the purposes of repositioning for correction or gating, which is the delivery of treatment only at a certain target position. AlignRT is one of the tools that tracks the skin's surface and takes a direct image of the patient to provide real-time feedback for any necessary adjustments. These devices have been used for respiratory gating with external surrogates and in the treatment of breast and prostate cancer. The applicability of this 1-2 mm geometric precision device is restricted to scenarios in which an external surface can serve as a dependable proxy for an inside position or motion.

A3. Electromagnetic Tracking System

These systems (like Calypso) use electromagnetic transponders, or beacons, that are embedded in the tumor. A detector array system can track the mobility of these beacons in real time. It is necessary to install beacons through a MR imaging artifact may be introduced by their existence, the process is minimally invasive, and patient size is restricted. With a geometric precision of less than 2 mm, Calypso is currently only used in prostate radiation.

A4. RI-Guided IGRT

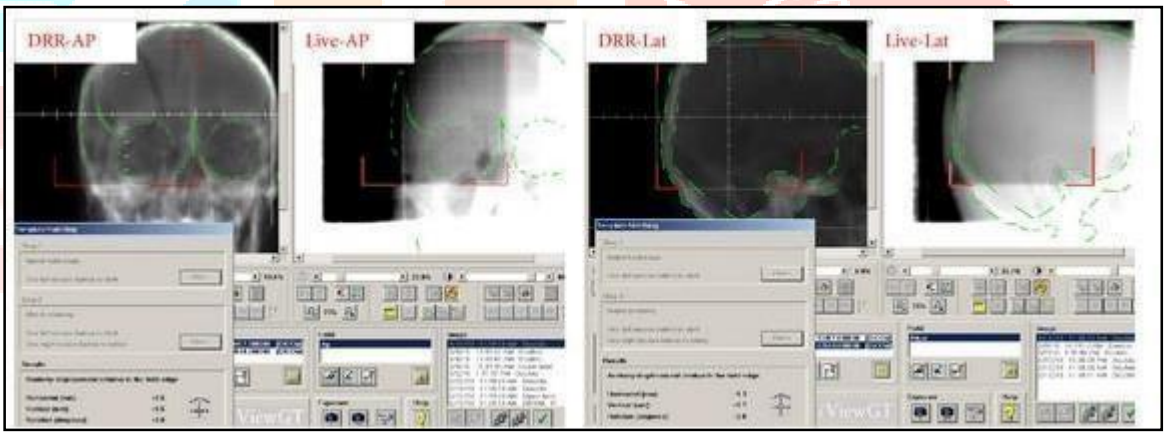
These systems, such as View Ray, provide intrafractional adjustments and aid in the real- time assessment of internal soft tissue structure and mobility through continuous soft tissue imaging. The system's geometric precision is 1-2 mm. MRIs, however, are not suitable for individuals who have metallic implants or pacemakers due to motion artifacts and distortion from uneven magnetic fields. For this IGRT system, all of the diagnostic MRI's limitations also apply. Numerous applications are possible for the treatment of the brain, liver, and prostate. concerning brachytherapy.

B. Radiation Based System

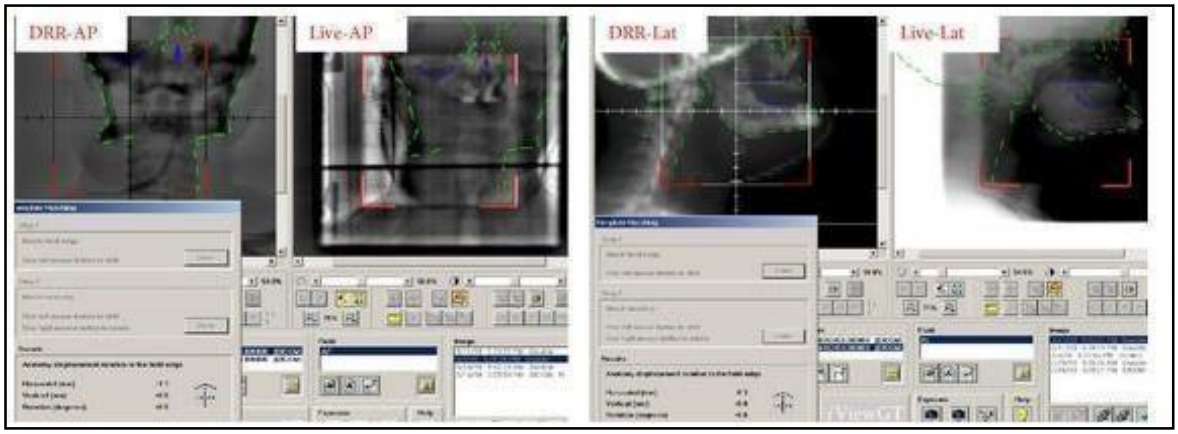
These include tracking in real time and in static modes, with kilovoltage (KV), megavoltage (MV), or hybrid techniques.

B1. Electronic Portal Imaging Device (EPID)

Based on indirect detection active matrix flat panel imagers (AMFPIs), EPID was created to replace film dosimetry for treatment field verification. Nearly all linear accelerator (LINAC) providers provide them as standard equipment, serving as instruments for both quality assurance (QA) and field verification. There is a 2 mm geometric accuracy in the 2D image acquisition. In order to define positional variations corresponding to the digitally reconstructed radiographs (DRRs) created from the planning CT dataset, bony landmarks on planar images are utilized as stand-ins (Fig. 9). KV or MV X-rays may be used by many systems for imaging, while KV images have better image contrast and MV images show reduced distortion from metallic implants (such as hip and dental prostheses). Rotations cannot be detected or quantified by EPID systems. For KV systems, the average dose per image is 1-3 mGy, however for MV systems, it can reach 30–70 mGy.



(a)



(b)

fig. 9: mv epid is utilized for online correction using orthogonal 2d pictures (lateral and anterior). to provide an estimate of error, the field and the bone structure are matched sequentially. rotational errors cannot be estimated; however, translational shifts can be evaluated and corrected by comparing the live image with the reference drr. (a) glioma parietal right. (b) cancer of the head or neck.

megavoltage (mv); electronic portal imaging device (epid); two-dimensional drr stands for digitally reconstructed radiograph; two-dimensional

B2. Fan Beam KV CT (CT-on-Rails)

The patient's treatment couch can be rotated in the direction of the gantry or the in-room CT scanner for imaging or therapy, respectively, with this technology. The patient is immobilized on the couch while 3D images are obtained. A multislice detector and a bigger hole size (>80 cm diameter) are used to accommodate cumbersome immobilization devices, which sets 3D imaging apart from diagnostic CT scanning. Applications and accuracy are comparable to CBCT, with a typical dosage of 10–50 mGy per picture.

B3. Fan Beam MV CT (Tomo Therapy Hi ART II)

The patient will be able to receive MV CT scans of themselves in the treatment position thanks to an on-board imaging system. Both of the treatment outcomes are produced using the same LINAC. (6 MV) and a 3.5 MV imaging beam. Exit data is gathered for the creation of MV CT images using a xenon detector on the gantry across from the LINAC. Pitch setting affects the patient dose from imaging, which is normally between 10 and 30 mGy each scan[20].

5. FORTIFICATION OF RISKS OF RADIOTHERAPY

Radiosensitizers and radioprotectors can be used to mitigate the negative effects of radiotherapy.Compounds known as radiosensitizers have the ability to both remove free radicals generated from cell damage and sensitize the tumor target itself. Among the radiosensitizers used to boost the effectiveness of RT treatment are hyperbaric oxygen, carbogen, nicotinamide, metronidazole, and hypoxia cell cytotoxic agents such mitomycin-c, tirapazamine, motexafin gadolinium, taxanes, and irinotecan.
Antioxidants make up the majority of radioprotectors, which can be used either before or duringRT to safeguard healthy cells. Among the radioprotectors are nitroxides and amifostine (Ethyol). Researchers and therapists are now taking an interest in Ayurvedic radioprotectors due to their minimal side effect profile. There are numerous ongoing preclinical and clinical investigations on plants' radioprotective properties.
Ayurvedic formulations like Triphala, Amritaprasham, Chyavanprasha, Brahma Rasayana, Narasimha Rasayana, and Ashwagandha Rasayana have been found in studies to be effective radioprotectors. These formulations work by scavenging free radicals, reducing oxidative stress, inhibiting DNA damage, and regenerating bone marrow progenitors through immunomodulatory mechanisms and anti-inflammatory chemoprotection.[21]

6. ROLE OF RADIATION THERAPY AS A STANDARD TREATMENT METHOD

RT is a first-line treatment for a number of head and neck cancer types. Clinical Stage (CS) I or II glottis carcinoma is one of the disease's representations. decisive radiation therapy (RT), with RT alone being able to cure 80–90% of glottis cancer cases in CS I. Chemoradiation therapy is the standard treatment for epipharyngeal cancer since most cases have undifferentiated carcinoma that is RT-sensitive. Eighty to ninety percent of patients treated with radiation therapy (RT) had early-stage epipharyngeal cancer. Additionally, RT was adopted as a standard treatment for malignant lymphoma in CS I or II, esophageal cancer in CS III, prostate cancer in CS I-III, uterine cervical cancer in CS I-IVA, and nonsmall cell lung cancer (NSCLC) in CS IIIB. In Japan, IMRT for prostate cancer, head and neck tumors, and brain tumors has been covered by insurance policies since 2008. Over the coming years, IMRT will expand in treatment for cancer, and it will lead to a reduction in the chance of late radiation morbidity, such as xerostomia following radiation therapy for head and neck tumors and rectal bleeding following radiation therapy for prostate cancer. It is anticipated that improved tumor management would result from dose escalation brought about by a risk reduction of radiation morbidity.

This decade has seen the publication of high-level data demonstrating the effectiveness of concurrent chemotherapy and radiation therapy for a variety of cancer types. For instance, at the 1999 annual meeting of the American Society of Clinical Oncology, all five of the randomized controlled trials of chemoradiation therapy for uterine cervical cancer revealed 30 to 50% of survival improvement by applying concurrent chemotherapy to RT. Applying the same protocol to Japanese women presents some challenges because patients'Features and RT techniques in those experiments were not the same as those in Japan.

However, if a good concurrent chemotherapy regimen is created for Japanese women, chemoradiation therapy may enhance treatment outcomes for uterine cervical cancer. Since Cooper et al. (1999) reported on the effectiveness of chemotherapy, it has also become a conventional treatment option for patients with medically treatable locally advanced esophageal cancer.

Radiation Therapy as an Alternative to Surgery

After insurance companies began to cover STI, which was first introduced by Leksell in 1951, it spread quickly throughout Japan and replaced surgery as the usual treatment for metastatic brain tumors that were less than 4 and had a maximum diameter of less than 3 cm. Over 85% of metastatic brain tumors have local control rates of STI. irrespective of the original lesion's susceptibility to radiation. In 2004, insurance packages that covered STIs also covered lung and liver tumors. At a median follow-up of 38 months, the local control rate of 257 patients with NSCLC in Stage I, as reported by Japanese institutes, was 86%, and no significant radiation morbidity occurred in those patients. Radiofrequency wave ablation and video-assisted thoracic surgery are two therapy approaches that compete with STI; nonetheless, from a low invasiveness perspective, STI is superior. Based on current clinical data, STI may replace surgery as a therapeutic option for medically operable NSCLC in Stage I.

In 2003, iodine-125 permanent implant therapy was introduced as a novel brachytherapy treatment modality. rather than surgery, for prostate cancer at low risk. The number of patients receiving treatment with Iodine-125 permanent implants is rising quickly due to its lesser invasiveness and strong tumor control rate, which is comparable to that of radical prostatectomy.

Radiation Therapy in Pallative Care

With RT's consistently high efficacy in controlling and relieving bone pain, neurological symptoms, obstructive symptoms, and tumor hemorrhage, it plays a significant role in cancer palliative care. Radiation therapy (RT) relieved symptoms in more than 80% of patients with superior vena cava syndrome and bone metastases. Palliative radiation therapy can reduce a patient's somatic burden from treatment with its low dosage of radiation and brief treatment duration. Patients can benefit from palliative RT even if their general health is compromised.

The occurrence of malignant spinal cord compression syndromespinal paraplegia affects 5% of cancer patients. With a limited prognosis, the patient's quality of life is declining due to this condition, necessitating an immediate and proper treatment strategy selection. The degree of neurological impairments at the onset of RT is the most significant factor determining the functional outcome, and RT must be started before the patient loses the ability to walk. Only 0–30% of those who experience paraplegia recover their ability to walk. RT is a treatment for various clinical problems associated with cancer that are referred to as oncologic emergencies[22].

7. CONCLUSION

New methods for the successful treatment of cancer are introduced by scientific and technological advancements. Some of the many radiation therapy techniques are currently in use, while others require additional research before they can be applied widely. Despite this, innovative cancer treatments like image-guided radiation therapy, conformal radiotherapy, and intensity-modulated radiation therapy have been developed. With continuous attempts to create innovative radiation treatment modes and procedures that continue to improve the survival and quality of life of cancer patients, radiation therapy is still a crucial part of cancer treatment. As the results of cancer treatments have improved, reducing the toxicities associated with radiation therapy has also gained importance. To further increase the therapeutic ratio of the radiation treatment, radiation is also given in conjunction with molecular targeted therapy.

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