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DOES IMRT TECHINIQUE WILL BE BASIC TREATMENT MODALITY IN RADIOTHERAPY DUE TO ITS BENEFITS

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Abstract : Radiotherapy has become one of the widely used modalities for treatment in an oncology setting, independent of whether the approach to treat cancer is either curative or palliative. As the technology evolved, we have incorporated many developments in cancer care radiotherapy treatment in day today life. It's well known that Intensity Modulated Radiotherapy (IMRT) is superiorly suited to most of the cases than 3Dimensional Conformal Radiotherapy (3D CRT). Since IMRT uses Multi Leaf Collimators (MLC) to deliver non-Uniform Intensity modulated beams. This is achieved with the help of Inverse planning treatment planning system available. Though 3D CRT also implements MLCs for delivery, it has limitations of fixing to the regular equivalent Field sizes, where unnecessary dose being delivered to normal structures or critical structures also. There is also possibilities of secondary malignancy development when unnecessary dose deposited other than Planning Target Volumes. Intensity modulated beams not only avoids critical structures but also vary the dose range called as Simultaneous Integrated Boost. This significant effect can be seen on the patient's quality of life even after cure of disease. An IMRT treatment plan though needs to be dosimetrically analyzed via, Patient specific Quality Assurance by both Point dose measurement and Fluence Verification.

IndexTerms - **Secondary malignancy, Intensity Modulated Radiotherapy, 3-Dimensional Conformal Radiotherapy, Inverse planning system, Multileaf collimators**

I. INTRODUCTION

Tumor is a group of diseases which has characteristic nature of uncontrolled growth and spread in abnormal cells. With a wide range of tumor types, there is a variety of approaches to treat cancer and manage patient's life care. The most common forms of treatment or cancer management is surgery, chemotherapy, and radiotherapy. Typically, several forms of treatment are combined to increase the chance of success. This is also guided by international guidelines. For example, surgery is often followed by chemotherapy and/ or radiotherapy to ensure the elimination of cancerous cells. Radiotherapy often forms part of the treatment for the patient due to its minimally invasive nature and sites have minimum accessibility for surgeons. It has been estimated that about 50% of all cancer patients have radiotherapy modality as part of their treatment protocol. A suitable patient being prescribed for radiotherapy treatment will generally have to first undergo several processes before the treatment: CT simulation (localisation of tumor or CT Isocentre) using a CT scanner or simulator, planning (clinicians deciding on the best way of delivering the amount of radiotherapy needed designating with appropriate dose and planning target volumes), and finally verification (of planning) using a Quality Assurance procedure. Treatment fields are the precisely defined at Tumor areas where the beams of radiation, varying by angle and intensity, will be targeted during treatment of the patient to destroy the cancerous cells. During treatment, ionising radiation like X-Rays or Gamma rays are delivered by a linear accelerator (linac) to those precisely defined treatment fields on the patient to shrink the cancerous cells with the help of day today imaging procedure of electronic portal imaging device.

Under Radiotherapy treatment there are several modalities of treatment delivery with many other techniques involved. Depending upon tumor growth, stages involved, and the site present the appropriate technique is chosen. Radiotherapy also has the category of treatment intent its been practiced, i.e) Curative or radical intent and Palliative intent. Keeping all these factors in mind and with international guidelines in practice, Radiation Oncologist choses the best suitable treatment.

For long period in radiotherapy, there has been several papers and debate has been happened on the net benefit of treatment to patients and their lifestyle or care after treatment delivery in both 3-Dimensional Radiotherapy and in comparison, with Intensity Modulated Radiotherapy. Each treatment has its own merits and demerits in the way from beginning to ending of treatment delivery. IMRT is more labor intensive than compared to 3D CRT. But Organ at risk preservation point of view IMRT plays vital role. Also, nowadays more data coming into picture of secondary malignancy due to unwanted dose deposition in site other than PTVs. So going through all these scenarios, in near future IMRT will become basic technique to start of radiotherapy treatment. To the extent of going forward there are possibilities of making basic components of linear accelerator starts with intensity modulated radiotherapy technique only along with portal verification device.

II. EVOLUTION IN RADIOTHERAPY FIELD:

Radio therapy is a clinical treatment modality dealing with the use of the ionizing radiations for malignant neoplasis [and occasionally benign diseases]. Predominantly external beam therapy - high energy (1-20 Mev) x –ray photons and/or electrons from linear accelerators (linacs)treatment. Since the inception of radiotherapy treatment and soon after the discovery of x-rays by Roentgen in 1895, the technology of x-ray production has first been aimed toward ever higher photon and electron beam energies and intensities, and more recently toward computerization and intensity-modulated beam delivery.

During the first 50 years of radiotherapy, the technological progress has been relatively slow and mainly based on x-ray tubes, Van de Graff generators and betatrons with experimental setups. The invention of the cobalt-60 teletherapy unit by H.E. Johns in Canada in the early 1950s provided a tremendous boost in the quest for higher photon energies and placed the cobalt unit into the forefront of radiotherapy for a number of years. The concurrently developed medical linear accelerators (linacs), however, soon eclipsed the cobalt unit, moved through five increasingly sophisticated generations, and became the most widely used radiation source in modern radiotherapy. With its compact, efficient design and user-friendly nature, the linac offers excellent versatility for use in radiotherapy through isocentric mounting and provides either electron or megavoltage x-ray therapy with a wide range of energies.

However, the machine development happened, the calculation of patient dose or treatment time and treatment delivery had also changed significantly. Olden day method of treatment time calculation was done manually with little parameters applied for treatment time calculations, which also include lead wire contouring in tracing sheet for locating tumor depths. Then came the era of computers taking the role of calculations, thereby reducing the time and manual errors associated with it. For computers to fed with anatomical data Computer Tomography images where used. This gave full-fledged use of 3Dimensional anatomical visualization of body structures. This also Helps in dose calculation to patients by pixel by pixel with dose volume histogram graphs.

The main distinction between treatment planning of 3-D CRT and that of conventional radiation therapy is that the former requires the availability of 3-D anatomic information and a treatment-planning system that can calculate 3-D dose distributions and dose-volume statistics for contoured structures. The main basic difference between the conventional therapy (including 3-D CRT) and Intensity modulated radiotherapy (IMRT) is that the latter provides an extra degree of freedom, that is intensity modulation, in achieving dose conformity.

The term intensity-modulated radiation therapy (IMRT) refers to a radiation therapy technique in which a non-uniform fluence is delivered to the patient from any given position of the treatment beam to optimize the composite dose distribution. The treatment criteria for plan optimization are specified by the planner and the optimal fluence profiles for a given set of beam directions are determined through "inverse planning." The fluence files thus generated are electronically transmitted to the linear accelerator, which is computer controlled, that is, equipped with the required software and hardware to deliver the intensity-modulated beams (IMBs) as calculated.

Moving forward of Intensity modulated beams, then came the scenarios of Volumetric Modulated Arc Therapy (VMAT). This VMAT offers wide variety of degrees of freedom in planning target volume coverage and OARs preservations. Degrees of freedom involved like variations in speed of collimator, leaf, gantry motion and even in dose rates. This enables in faster treatment delivery also. With many controversies and radiobiological implications, Stereotactic Radiosurgery (SRS), Stereotactic Radiotherapy (SRT) and Stereotactic Body Radiotherapy (SBRT) came into existence. The outcome of these modalities were quite challenging and very appealing in-patient care also. So very easy it has found its place of growth among radiotherapy community. The aim SRT, SBRT is delivering high dose in shorter fractionation schedule. The chance of regrowth is eliminated in this technique. Next came the technologies of Tomotherapy and Cyber Knife. Apart from treatment delivery as per treatment planning system planned on board image verification of treatment also parallelly evolved with many changes. From orthogonal 2Dimensional radiographs to 3Dimsional imaging to cone beam beam image acquisition, which is well known to be now Image Guided Radiotherapy. Altogether these technology evolvements gave ultimate patient treatment outcomes and sophistication in radiotherapy treatment techniques.

III. WHAT WE ARE NOW AND FUTURE SCENARIO:

Extensive literatures are available in each site of tumor for comparative study on 3D CRT and IMRT on dosimetric aspects. We have chosen 3 each literature for different tumor sites like Brain, Head and Neck, Breast, Lung, Gynecology and Prostate. All these literatures are being presented in Table 1. Each of the study with their conclusion's states that their effective use of IMRT in tumor control probability and meeting OAR constraints plays vital role. Those literature presented here are in view of radical point of view patient care. Though palliative patient care is of pain management, if it can be implemented with low profile IMRT planning parameters, so that treatment time and planning time can be reduced. Then unnecessary dose deposited to other areas other than PTV can be eliminated.

Each of the sites like brain, head and Neck, Breast, Lung, Gynecology and prostate has its own benefit of IMRT planning versus 3D CRT planning's. Brain site has the benefit of saving Optic chiasm, brain stem and Optic nerves. Avoiding irradiation to whole brain as in case of 3D-CRT, which may lead to alopecia. In case of Head and Neck cases primary usages will be of saving spinal cord and parotids. Also, Simultaneous Integrated Boost dosage can be implemented. Coming to Breast site, IMRT will have benefit of saving Lung and Heart volumes.

As the lung literatures reviews, there is benefit of saving other lung volume, spine and to some extend of heart doses. This treatment can be effectively managed with the help of 4D CT and Automatic Breath Control devices. Pelvis case of IMRT planning has benefit of nodal involved site along with Simultaneous Integrated planning as the case of Head and neck IMRT planning's. If 3D CRT planning is involved then OAR like femoral head, bladder, rectum and bowel will be at high risk.

S.No	Year of Publications	Author	No.of Patient Studied	Cancer Site considered	Conclusion
1	2007	Meisong Ding et al. [1]	8	Brain	We found that IMRT significantly improved the target dose homogeneity compared to the 3DCRT. However, IMRT showed the same radiobiological effect as 3DCRT. For the brain tumors adjacent to (or partially overlapping with) critical structures, IMRT dramatically spared the volume of the critical structures to be irradiated.
2	2012	S Lorentini et al. [2]	17	Brain	A statistically significant dose reduction to the healthy brain in favor of IMRT was scored. IMRT seems a superior technique compared to 3D-CRT when there are multiple overlaps between OAR and PTV. In this scenario, IMRT allows for a better target coverage while maintaining equivalent OARs sparing and reducing healthy brain irradiation.
3	2007	Shannon M. MacDonald et al. [3]	20	Brain	Intensity-modulated radiation therapy improved target coverage and reduced radiation dose to the brain, brainstem, and optic chiasm. With the availability of new cancer imaging tools and more effective systemic agents, IMRT may be used to intensify tumor doses while minimizing toxicity, therefore potentially improving outcomes in patients with high-grade glioma.
4	2016	Gopa Ghosh et al. [4]	80	HN	IMRT was associated with a significantly lower incidence of Grade 3 or greater xerostomia, acute toxic effects to skin and mucous membranes than 3D-CRT. In addition, compared to 3D-CRT, IMRT had lower rates of Grade 3 or greater mucositis and skin toxicity as well as less feeding tube use during radiotherapy. Our analysis showed potentially less toxicity in patients treated with IMRT in comparision to 3D-CRT
5	2014	Shivangi Lohia MD et al. [5]	159	HN	The use of IMRT significantly improves PEG tube and toxicity-related outcomes compared with 3D-CRT in the treatment of oropharyngeal primary cancers. Given the association between mucosal toxic effects, PEG tube dependence, and dysphagia, these findings may be an indication of improved swallowing outcomes with IMRT.
6	2014	Micheal T Spiotto et al. [6]	379	HN	Compared to 3D-CRT and IMRTseq, IMRT+SIB provided similar outcomes and potentially less toxicity indicating it is a feasible technique for chemoradiation in locally advanced head and neck cancer.
7	2017	Karthick Rastogi et al. [7]	107	Breast	IMRT significantly improves the conformity of plan and reduce the mean dose and High dose volumes of ipsilateral lung and heart compared to 3DCRT.
8	2012	Suresh Moorthy et al. [8]	27	Breast	IMRT reduces maximum doses and improves conformity and Homogeneity indices of target volumes,also reduces dose to OAR
9	2011	Volker Rudat et al. [9]	20	Breast	Tangential beam IMRT significantly reduced the dose-volume of the ipsilateral lung and heart in unselected postmastectomy breast cancer patients.

10	2004	Hasan Murshed MD et al. [10]	42	Lung	Using IMRT, the median absolute reduction in the percentage of lung volume irradiated to >10 and >20 Gy was 7% and 10%, respectively. This corresponded to a decrease of >2 Gy in the total lung mean dose and of 10% in the risk of radiation pneumonitis.
11	2016	John Boyle MD et al. [11]	24	Lung	IMRT significantly decreased unnecessary dose to critical organs with equivalent coverage of planning target volumes. IMRT may therefore improve the tolerability of therapy.
12	2005	Sue S Yom MD et al. [12]	151	Lung	IMRT resulted in significantly lower levels of Grade ≥3 TRP compared with 3D-CRT
13	2012	Baojuan Yang et al. [13]	455	Gynec	IMRT-delivered high radiation dose produced significantly less average percent volumes of irradiated rectum and small bowel than 3D-CRT
14	2018	Yanzhu Lin et al. [14]	1008	Gynec	IMRT and conventional radiotherapy demonstrated equivalent efficacy in terms of 3-year OS and DFS. Additionally, IMRT significantly reduced acute GI and GU toxicities as well as chronic GU toxicity in patients with cervical cancer
15	2018	H Lou et al. [15]	398	Gynec	IMRT has shown a dosimetric advantage and also provided good quality of life for the postoperative patients with cervical cancer compared to 3D-CRT.
16	2013	Bora Uysal et al. [16]	20	Prostate	It can be concluded that IMRT is an effective definitive management tool for prostate cancer with improved critical organ sparing and excellent dose homogenization in target organs of prostate and seminal vesicles.
17	2005	Maria T Vlachaki et al. [17]	10	Prostate	This study demonstrates that IMRT achieves superior normal tissue avoidance, especially for rectum and femurs compared to 3DCRT, with comparable target dose escalation.
18	2006	Alice Wang chesebro et al. [18]	35	Prostate	IMRT improved pelvic nodal coverage while decreasing dose to bladder, rectum, small bowel, and penile bulb. For patients with extended node involvement, IMRT especially decreases small bowel dose.

IV. RESULTS AND DISCUSSION

Going through all those represented data, or the literature collected, we could some extend make a point that IMRT will be standardized radiotherapy treatment of patient care in near future. The machine basic requirement can be set to that of Intensity Modulated Radiotherapy with basic imaging device for patient positioning. This is what we have achieved so far and moving forward to eradicate the extra or unnecessary dose deposited in patient volume, this technique can be employed. Also, to note that unwanted dose being deposited other than clinical target volume may to some extend give rise to secondary malignancy. This factor can also be reduced if IMRT being used in even palliative patient care.

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