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Review

External beam radiation techniques for breast cancer in the new millennium: New challenging perspectives

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Abstract Radiation therapy in breast cancer has evolved dramatically over the past century. It has traveled a long path touching different milestones and taking unprecedented turns. At the end, a fine tune of clinical understanding, skill, technological advancement and translation of radiobiological understanding to clinical outcome has taken place. What all these have given is better survival with quality survivorship. It is thus prudent to understand breast irradiation in a new perspective suitable for the current millennium.

Contents

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Introduction

Breast cancer is one of the human cancers where therapeutic use of radiation has evolved dramatically over the past century. The journey is eventful which started with brachytherapy and still continuing in parallel to the most modern external beam radiation techniques. Slowly but steadily the use of fascinating sophisticated external beam radiation techniques is getting a foothold. Though parallel opposed tangent beams are considered standard technique till now, use of conformal radiotherapy with its full array including intensity modulation, image guidance, respiratory motion management and stereotaxy are in vogue and gaining pace. Whereas tangent beam is simple and easy to deliver, many of the new techniques are complex, time consuming, difficult to implement in large volume centers and not without risk of uncertainty. The resultant gain in therapeutic advantage is often questioned and associated risk of long term radiation damage from the newer techniques due to their inherent nature is promulgated as a major deterrent for their use.

It took a long time to establish the role of radiation as an essential component in adjuvant treatment of breast cancer. Radiation after BCS (Breast Conserving Surgery) for early as well as locally advanced tumor after neoadjuvant chemotherapy (NACT) is now considered as an integral part of BCT (Breast Conserving Therapy) whereas postmastectomy radiation (PMRT) to chest wall and or regional area is considered beneficial for a select group of high risk patients [1–5]. This group comprises of patients with four or more node positive diseases, extranodal extension of tumor, chest wall invasion by tumor, presence of tumor at the resection margin or having lymphovascular space invasion. The role of radiation in 1–3 positive nodes after mastectomy has always been an area of debate. However, a recent meta-analysis supports the use of radiation for this patient group also [6]. The meta-analysis conclusively supports beneficial role of postmastectomy radiation in patients with 1–3 positive nodes to reduce recurrence and breast cancer mortality.

In a very interesting multicenter study, patients with positive sentinel lymph node biopsy were randomized to receive either axillary radiation or underwent axillary dissection [62]. Patients receiving axillary radiation showed significantly less arm edema. This will definitely lead the way for nodal irradiation in future with improved quality of life.

A complex relationship exists between the tumor, its biology, host and treatment related parameters which ultimately dictates curability and thus giving rise to chance of a long term radiation induced morbidity in survivors. The choice of radiation technique is thus crucial to provide cure and mitigate the risk of long term complications. 2D planning is still the gold standard and as technology advanced, 3DCRT, IMRT with or without simultaneous integrated boost (SIB), arc therapy, Tomotherapy, stereotactic body radiotherapy (SBRT), and proton therapy are becoming more crucial for clinical use. Dosimetric studies are ample in literature and clinical use seems promising. Long term cardiac risk from the effect of radiation, particularly for left sided breast cancer is a concern for this favorable group of patients. New technologies are useful in reducing cardiac dose and thus can help in reducing long term cardiac morbidity and mortality. Another important breakthrough in the last two decades is establishment of hypofractionation as standard of care in many developed countries for whole breast radiation as part of BCT. For shortage of space, different dose fractionation schedule combined with radiation techniques will be discussed as a whole.

History of external beam radiotherapy in breast cancer

The journey of external beam radiation started in the last century with superficial X-rays and gradually moved on to high energy X-rays and photons including radionuclides like 60-Co (radioactive Cobalt) and 37-Cs (Cesium). The revolution in radiation oncology began post Second World War, with development of telecobalt followed by high energy linear accelerator in 1950 s. However it was only in 1960–1970 when linear accelerators came more into practice for therapeutic medical indications. This period is thus popularly called megavoltage era [7]. Changes were notably apparent in technical aspects of radiation, starting from manual surface marking based planning to adoption of computer and software. The advent of computed tomography (CT) scan in the field of radiation oncology further added to the sophistication with its robust use in simulation, segmentation, dose and inhomogeneity correction which all together brought a significant change toward individual patient based planning compared with earlier 2D standard planning techniques. Modern linear accelerators are also equipped with different imaging facilities which made patient positioning and treatment delivery precise thus providing the opportunity of reducing target volumes. All of these essentially lead to a theoretical dogma of less radiation induced morbidity. Again, for breast cancer, most of which are detected very early with increased patient awareness, thus giving rise to the issue of long term survivorship, the use of new technology must be well planned and thought to avoid morbid survival. With the ray of hope in sight, thus, toxicity reduction, notably skin toxicity, cardiac toxicity and ischemic heart disease, pulmonary toxicity and risk of pulmonary fibrosis seem to be manageable and reducible. This again, has been said with caution, given the young age of these modern techniques and lack of data to prophesize the future.

Modern planning and verification

Positioning and breathing motion

Conventionally, radiotherapy to breast is delivered in supine position with arms abducted beside head. Breast board is used for selected patients with significant chest wall angulation to make the anterior chest wall horizontal. Selected patients merit

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