X-Ray Breast Brachytherapy Instead Of ^{192}Ir Mammosite Balloon Brachytherapy

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Abstract: Efforts nowadays are looking for the tumor itself and organs surrounding it to give high doses to tumor itself with low doses to adjacent organs. The researchers found that the use of a new technology uses x ray techniques can offer some of what they are looking for. It can be used in cases of small distance between the breast skin and the edge of the lumpectomy cavity. The low energy used by x-ray source is an advantage for sparing sensitive organs around the tumor cavity.

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Index Terms: Brachytherapy, MammoSite brachytherapy, electronic brachytherapy

1 Introduction

THE difference between x-rays and gamma radiation is that while x-rays are emitted outside the nucleus by electron transmissions between orbits, gamma rays are emitted by the nucleus itself [1], but both can penetrate some of densest materials making a great benefit or hazard, and the profound effect on human health is for gamma which is more energetic [2]. There are different interaction ways between them and matter include coherent scattering with no real effect, photoelectric absorption with small effect produces free radical atoms and free electrons(photo-electrons or Auger electrons), Compton scattering (30 keV - 30 MeV) which is the main effect by producing Compton electrons (~75% of radiation damage) and free radical atoms (~25% of radiation damage), pair production that has smaller effect and the photo disintegration that has no real effect [3].

2 MammoSite balloon brachytherapy (MBB)

MBB is a partial irradiation for the breast; its device has a silicone balloon with dual catheter: the central one is for HDR ^{192}Ir source, and the other is a channel for inflation, and it is filled with saline solution with radiographic contrast (<10%) that help in imaging to check balloon symmetry (<2mm of the central dwell position from its centre) [4, 11, 13], the balloon will be inflated at the time of insertion of catheter into lumpectomy cavity (the remove of tumor and surrounding normal tissues) inside the breast [11]. The dose passes the surface of balloon with smallest and largest diameter (4-6 cm); will have reduction rates of 9% and 12% respectively [9]. The main limiting of its use are the surface-skin distance (in contact with lumpectomy cavity surfaces), and tissue conformances (by the measurement of percentage of the seroma and air pockets between lumpectomy cavity and balloon surfaces within 10% and more than 7 mm between the surface of balloon and skin, or between 5-10 mm in the superior-inferior direction) [4, 10, 11].

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It can be used for low dose rate (LDR) [5], high dose rate (HDR) [4] and for Xoft Axxent electronic brachytherapy (KVB) [7]. Early results exist the successful use of MBB with a fast effective treatment [6, 16, 20], a good coverage of target volume [7], low toxicities[8, 11, 17], in major outcomes has excellent cosmetic, demonstrated local recurrence results [8, 10, 16], the side effects can be moderated, clinically performed well [10], with easier implantation (one applicator) to the breast tissue than conventional brachytherapy (multi-catheter), shorter treatment time, it is suitable in breast conservation therapy that alternates external beam radiation therapy [11, 13, 16, 18], with dose homogeneity more than conventional interstitial brachytherapy but with higher dose to lung and skin [12, 13, 15, 16], and negligible dose to ribs [17] but higher dose rate to ribs fractures, breast pain and fat necrosis [20], it is 25% the risk to irradiated healthy tissue compared with whole irradiation to breast with procedure of 15 minutes under local anesthesia, but may cause widening of capillaries [18]. Patients with MBB has more risks than with WBI in surveillance period to unscheduled imaging, seroma formation, or aspiration / biopsy [19], 4% of them have cancer come back [20]. MBB device has a special design to get over technical difficulties yielded from multi catheter based interstitial brachytherapy and the scheduling problems linked to external radiotherapy. By the time the surgeons removed tumor from the infected breast or later by the use of ultrasound guidance; the MammoSite catheter could be placed at the lumpectomy cavity. 80 to 90% of treated patients had good or excellent cosmetic outcomes at one year of MBB, but early side effects with the comparison of traditional conserving therapy [21].

3 Electronic Brachytherapy (eBx)

The electronic brachytherapy is based on the use of balloon catheter inside lumpectomy cavity at breast. It applies interstitial x-ray irradiation without the need for radionuclide source. One of the novel method of APBI is electronic brachytherapy developed by Xoft Inc. Canada, and called Xoft Axxent, which uses x-rays by an electronic source, it delivers less radiation to normal tissues with high spots to the target volume [22, 23]. It is more accessible to patients with breast cancer; it uses x-rays produced by an electronic source with no need for traditional brachytherapy facilities that makes it accepted by patients and applicable to many hospitals and cancer care centers [23]. The Xoft Axxent BBT uses an electronic source with 50-kV source with anisotropy of isodose at the proximal end of its catheter that can optimize dose to

skin when the distance between lumpectomy cavity and skin is small [24]. The miniature x-ray source tube has a miniature size with diameter of 1 cm and uses a carbon nanotube field emitter (CNT) with a diameter between 0.25 to 0.8 mm, a structure of simpler cathode is used for miniaturization of x-ray tube, beryllium and tungsten coating emit three dimensional uniform x-rays, and it has a focusing electrode [25]. The electronic brachytherapy has two common types; Intraoperative Radiation Therapy (IORT) and Accelerated Partial Breast Irradiation (APBI). By IORT and during lumpectomy surgery; a single dose of radiation is delivered by placing inflatable balloon into the lumpectomy cavity which contains the x-ray source in efficient and quick procedure that takes eight minutes during surgery. After this radiation delivery, the treatment is completed and the balloon is removed. But by APBI; balloon is inserted during the lumpectomy surgery and irradiation will be delivered after surgery for five days [47].

4 Comparison

The dose reaches the tumor in early breast stages via two brachytherapy techniques (electronic (50 kV) or ^{192}Ir brachytherapy) is the same [26, 27, 31, 34, 41], with lower toxicity by x-rays to most healthy tissues [34, 40] except ribs near the breast[6], in the vaginal brachytherapy, x-ray and the ^{192}Ir techniques have the same coverage but with the increase of sparing of both bladder and rectum by x-ray technique [29, 32, 42]. The need of shielding and HDR ^{192}Ir afterloader device makes many centers not to have a brachytherapy department [31], The electronic brachytherapy device has developed to offer many advantages over HDR ^{192}Ir brachytherapy like radiation safety, shielding, more flexibility, less treatment time [34], it offers a convenient, portable, nonisotope source [43], and delivers electronically generated low x-rays output energy, that has a constant energy value not like radioisotopes [33]. The efficacy or patient outcomes, calibration standards and effects on tumor and normal tissues are not yet well understood of the electronic brachytherapy make the American Society for Therapeutic Radiology and Oncology (ASTRO) In 2010 to have some doubts about it [33], but late in 2010 Rong and Welsh methodology provides comprehensive calibration procedures for skin applicators and electronic brachytherapy system for the treatment of nonmelanoma skin cancer [46]. Beitsch et al. 2010, explained that electronic brachytherapy was reliable and well tolerated for early stage breast cancer by their observational, nonrandomized, and multicenter study [37]. It appeared acceptable early outcomes (acute safety and favorable cosmetic) for the treatment of non-melanoma skin cancer with a convenient schedule of the treatment. In June 2012, Patel et al. explained that in the early stage breast cancer surgery and electronic brachytherapy, at 1 and 2 years there have been no recurrences reported with acceptable adverse effects [38]. A retrospective analysis for early stage breast cancer showed that it can be administered using electronic brachytherapy with similar toxicity outcomes like ^{192}Ir [38, 41, 43, 44, 45], it delivers a logical and comfortable mode intraoperative radiotherapy [44], but some are not sure about the outcome and in need for further research and longer follow-up data to give final judge on it [31, 32, 35, 44]. Xoft Axxent BBT delivers lower skin dose than MBB , better tumor cavity coverage and improved cosmetic outcomes if the distance between skin and lumpectomy cavity is small [24].

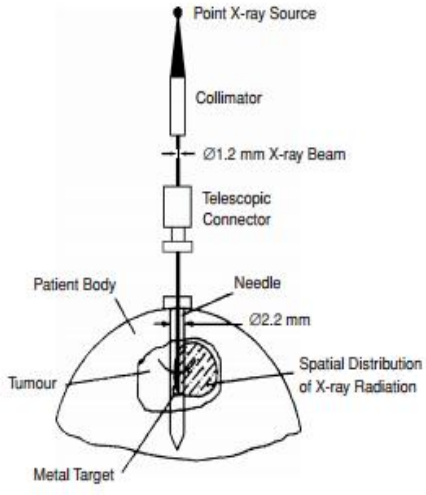

Figure 1. *miniature x-ray generator system used as eBx brachytherapy [48].*

5 Conclusions

The need for radiation therapy after lumpectomy is to reduce the local recurrence not only in elderly women [14, 18]. Many researchers found it better to use Xoft Axxent BBT at cases have a small distance between lumpectomy cavity and skin. It can be controlled by on/off switch to stop radiation source which helps staff to be safe from exposure. The unproven clinical applications without any calibration protocol and its large size made it unacceptable for some physicians, so the need for micro eBx and a calibration protocol with future research about its clinical applications will develop the radiation delivery scenarios and help patients anywhere to have the electronic brachytherapy instead of the whole breast radiotherapy or other APBI. The basic dosimetry of electronic brachytherapy is required to evaluate the delivered dose to be as a prescribed dose [49].

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