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# Boosting the tumor bed from deep-seated tumors in early-stage breast cancer: A planning study between electron, photon, and proton beams

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ABSTRACT

*Purpose:* To assess the potential dosimetric advantages and drawbacks of photon beams (modulated or not), electron beams (EB), and protons as a boost for the tumor bed in deep-seated early-stage breast cancer.

*Material and methods:* Planning CTs of 14 women with deep-seated tumors (i.e., ⩾4 cm depth) were selected. The clinical target volume (CTV) was defined as the area of architectural distortion surrounded by surgical clips. The planning treatment volume (PTV) was the CTV plus 1 cm margin. A dose of 16 Gy in 2 Gy fractions was prescribed. Organs at risk (OARs) were heart, lungs, breasts, and a 5-mm thick skin segment on the breast surface. Dose–volume metrics were defined to quantify the quality of concurrent treatment plans assessing target coverage and sparing of OAR. The following treatment techniques were assessed: photon beams with either static 3D-conformal, dynamic arc (DCA), static gantry intensity-modulated beams (IMRT), or RapidArc (RA); a single conformal EB; and intensity-modulated proton beams (IMPT). The goal for this planning effort was to cover 100% of the CTV with ⩾95% of the prescribed dose and to minimize the volume inside the CTV receiving >107% of the dose.

*Results:* All techniques but DCA and EB achieved the planning objective for the CTV with an inhomogeneity ranging from 2% to 11%. RA showed the best conformity, EB the worst. Contra-lateral breast and lung were spared by all techniques with mean doses <0.5 Gy (zero for protons). The ipsi-lateral lung received a mean dose <10% of that prescribed with photon beams and <2% with IMPT, increasing to 17% with EB. The heart, in left-sided breast tumors, received also the highest dose with EB. The skin was best protected with RA with a mean dose of 5.4 Gy and $V_{15Gy}$ = 2.4%.

*Conclusions:* Boosting the tumor bed in early-stage breast cancer with optimized photon or proton beams may be preferred to EB especially for deep-seated targets. The marked OAR (i.e., ipsi-lateral breast, lung, heart, and skin surface) dose-sparing effect may allow for a potential long-term toxicity risk reduction and better cosmesis. DCA or RA may also be considered alternative treatment options for patients eligible for accelerated partial breast irradiation trials.

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Breast-conserving surgery followed by whole breast radiation therapy (WBRT) and a boost to the tumor bed is the treatment of choice for most patients with stages I–II breast cancer. Not only are disease-free and overall survival rates after such treatment comparable with those of patients treated by mastectomy [1,2] but in addition breast-conserving therapy offers an obvious cosmetic advantage that may enhance quality of life and lead to less psychological and emotional treatment-related distress [3].

The rationale for boosting the tumor bed is based on the hypothesis that higher local control rates may be achieved if a higher dose of radiation is administered to the region of the breast bearing the greatest tumor burden [4]. Although the use of a tumor bed boost (10–20 Gy, depending on tumor size and surgical margins) is routine practice, there is no standard treatment delivery technique. Some authors recommend the use of interstitial implants but most studies report the use of electron beams (EBs) to boost the tumor bed [5,6]. Most frequently, single 9–12 MeV EB with 2–3 cm margin around the estimated tumor bed is used. Such energy range helps to adequately treat shallow targets inside the breast. Deep-seated tumors, however, may not adequately be treated with EB, though contemporary highly conformal photon beam techniques may be able to reduce the dose inhomogeneity within the target while optimally decreasing the dose to the surrounding non-target tissues.

The present study aimed to assess the potential dosimetric advantages and drawbacks of the following treatment techniques:

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