Factors influencing eligibility for breast boost using noninvasive image-guided breast brachytherapy

Jaroslaw T. Hepel1,2,*, Kara L. Leonard1,2, Jessica R. Hiatt1, Thomas A. DiPetrillo1,2, David E. Wazer1,2

1Department of Radiation Oncology, Rhode Island Hospital, Brown University, Providence, RI
2Department of Radiation Oncology, Tufts Medical Center, Tufts University, Boston, MA

ABSTRACT

PURPOSE: Noninvasive image-guided breast brachytherapy (NIBB) allows for accurate targeting of the tumor bed (TB) for breast boost by using breast immobilization and image guidance. However, not all patients are candidates for this technique.

METHODS: Consecutive patients treated for breast cancer were evaluated. Patients with very small breast size (cup A) for whom immobilization could not be achieved were treated with electrons. All others underwent simulation for NIBB boost. The rate of eligibility for NIBB, reasons for ineligibility, and related patient and anatomic factors were analyzed.

RESULTS: Of 52 patients evaluated, 6 patients were ineligible for NIBB because of small breast size. Of the remaining patients who underwent simulation for NIBB boost, 33 patients (72%) were treated with NIBB. Reasons for ineligibility were the absence of identifiable TB (n = 5), inability to position patient/breast to adequately target the TB (n = 4), posterior TB location (n = 3), and discomfort during compression (n = 1). The likelihood of being eligible for NIBB boost was dependent on breast size: ≤A (0%), B (50%), C (71%), D-DD (77%), and >DD (80%) (p = 0.002). The presence of surgical clips also predicted eligibility for NIBB: 79% clips vs. 45% without clips (p = 0.05). A posterior TB location was not associated with ineligibility (p = 0.2).

CONCLUSIONS: NIBB boost is feasible in most patients. Patients with larger breast size are more likely to be good candidates. Posterior TB location can be challenging for NIBB, but most patients are still candidates. Surgical clips are very helpful in defining the TB and greatly increase the likelihood of eligibility for NIBB.

Keywords: Noninvasive image-guided breast brachytherapy; NIBB; Accuboost; Breast boost; Breast cancer

Introduction

Breast boost, as part of adjuvant whole breast irradiation after breast conserving surgery, has been shown in Phase III randomized trials to decrease the rate of ipsilateral breast tumor recurrence (1, 2). Noninvasive image-guided breast brachytherapy (NIBB) is a novel method to precisely deliver breast boost by using breast immobilization and imaging for each treatment fraction. NIBB has been validated dosimetrically (3–5), and early clinical outcomes have shown favorable results with this technique (6–8). However, not all patients are ideal candidates for this approach. The aim of this study was to identify the rate of eligibility for NIBB and determine patient and anatomic factors that influence eligibility.

Methods

From April to November 2013, consecutive patients with early stage breast cancer treated with breast conserving therapy who were candidates for breast boost
were analyzed. This study was conducted in accordance to and approved by our institutional review board. Patients with very small breast size (cup size A or smaller) for whom breast immobilization could not be achieved with compression did not undergo NIBB simulation. These patients were treated with en face electrons. All other patients underwent simulation for NIBB boost. Both NIBB simulation and boost treatment were performed on the AccuBoost System (Advanced Radiation Therapy, Inc., Billerica, MA). Simulation consisted of breast immobilization between compression plates on the AccuBoost System followed by kilovoltage imaging (Fig. 1). The tumor bed (TB) was localized using postsurgical changes and/or surgical clips placed at the time of surgery to delineate the lumpectomy cavity. Whole-breast CT simulation and preoperative imaging (mammography and/or MRI) were used to assist in TB identification. To be eligible for NIBB boost, the TB had to be identified by the treating physician and encompassed by an available applicator. Furthermore, patients had to achieve a separation of ≤10 cm with compression. For boost, the target volume consisted of the TB without need for additional planning target volume margin expansion. Patients who met eligibility criteria on simulation underwent NIBB boost in the immobilized position with breast compression using specialized applicators and a remote afterloaded iridium-192 high-dose-rate source. The NIBB technique has been previously described in detail (5, 9). Patients who were found to be ineligible for NIBB on simulation underwent boost treatment with either en face electrons or three-dimensional (3D) conformal photons. The rate of eligibility for NIBB and reasons for ineligibility were evaluated. Eligibility for NIBB boost was analyzed for association with patient and anatomic factors using the χ² and Student’s t tests. A p-value of <0.05 was considered statistically significant.

Results

A total of 52 patients who were candidates for breast boost were evaluated. Six of these patients were ineligible for NIBB because of small breast size and thus, were treated with en face electrons. Of the remaining patients who underwent simulation for NIBB boost, 33 patients (72%) were treated with NIBB. The reasons for ineligibility were the absence of identifiable TB in 5 patients, inability to position the patient or patient’s breast in such a way to adequately target the TB in 4 patients, a posteriorly located TB that abutted the chest wall in 3 patients, and discomfort during breast compression in 1 patient.

The likelihood of being eligible for NIBB boost based on breast size, breast quadrant, and the presence of surgical clips is shown in Table 1. The eligibility for NIBB was significantly associated with breast size (p = 0.002). Patients with breast cup size B, C, D-DD, and O-DD were eligible at rates of 50%, 71%, 77%, and 80%, respectively. Patients with tumors located in the central breast or upper outer quadrant were more likely to be eligible for NIBB boost than those with tumor located elsewhere in the breast, although this did not reach statistical significance (p = 0.07). Surgical clips placed at the time of surgery to define the TB were helpful to identify the TB for targeting and significantly associated with eligibility for NIBB boost. Patients with no surgical clips were candidates for NIBB only 45% of the time, whereas those with clips were candidates

Fig. 1. (a) The AccuBoost System. (b) Noninvasive image-guided breast brachytherapy treatment using breast immobilization via gentle breast compression, image guidance, and specialized applicators for an iridium-192 high-dose-rate source.
79% of the time ($p = 0.05$). A posteriorly located TB can be a challenge for NIBB as it may be difficult to position the entire TB on the localization grid between the compression plates. However, 73% of posteriorly located TBs were still eligible for NIBB boost, and a posterior location was not associated with a statistically significant lower rate of eligibility compared with a nonposterior location ($p = 0.2$).

### Discussion

The importance of boost as part of whole-breast irradiation has been established by two randomized controlled trials (1, 2). Both the European Organisation for Research and Treatment of Cancer and the Lyon trials showed improvement in local control with boost. Traditionally, boost was delivered using *en face* electrons using a clinical setup. This has been shown to be inaccurate particularly in the modern era of cosmetically conscious surgery using small incisions that may be remote from the TB and using oncoplastic cavity reconstructions (10–14). Although 3D treatment planning improves targeting accuracy, it does not eliminate the inaccuracies of daily clinical setup and motion of the breast, an organ that can be easily deflected by respiratory and/or patient movement. NIBB is a method by which precise targeting of the TB can be achieved for each treatment fraction by using breast immobilization via gentle compression and image guidance. Furthermore, by using compression to move nontarget breast tissue out of the treatment field and by using two orthogonal treatment axes, conformal treatment that spares lung and heart exposure can be achieved.

However, NIBB is not without its limitations. Currently, NIBB planning is limited to two-dimensional planning. Patient-specific 3D planning is not yet available because of the challenge of summing dose between the two treatment angles given the significant tissue deformity with breast compression in each orthogonal axis. Another important limitation of the NIBB technique is that not all patients are eligible for this approach. To be eligible for NIBB, the breast needs to be immobilized between the compression plates, TB needs to be identifiable, TB needs to be able to be positioned on the targeting grid between the compression plates, TB needs to be encompassed by one of the available applicators, the breast separation with compression needs to be $\leq 10$ cm, and the patient has to tolerate the procedure. The most important of these elements are the first three. No patient in this study was unable to achieve a breast compression of $\leq 10$ cm or not have their TB encompassed by one of the available applicator sizes. Although both of these are potential eligibility limitations in this study and our broader experience with NIBB boost, these have been rare events. One patient in our study did not tolerate NIBB because of discomfort. This patient had a tense postoperative seroma but declined aspiration. The purpose of breast compression with the NIBB technique is to achieve breast immobilization, and thus compression should not be at the level of that which is used with diagnostic mammography. With appropriate communication with the patient during the

### Table 1

Factors influencing eligibility for NIBB boost

<table>
<thead>
<tr>
<th>Patient/anatomic factor</th>
<th>Eligibility (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast size (cup size)</td>
<td></td>
</tr>
<tr>
<td>A or smaller</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>50</td>
</tr>
<tr>
<td>C</td>
<td>71</td>
</tr>
<tr>
<td>D-DD</td>
<td>77</td>
</tr>
<tr>
<td>&gt;DD</td>
<td>80</td>
</tr>
<tr>
<td>$p = 0.002$</td>
<td></td>
</tr>
<tr>
<td>TB location</td>
<td></td>
</tr>
<tr>
<td>Central breast</td>
<td>100</td>
</tr>
<tr>
<td>Upper outer quadrant</td>
<td>72</td>
</tr>
<tr>
<td>Upper inner quadrant</td>
<td>67</td>
</tr>
<tr>
<td>Lower outer quadrant</td>
<td>38</td>
</tr>
<tr>
<td>Lower inner quadrant</td>
<td>25</td>
</tr>
<tr>
<td>$p = 0.07$</td>
<td></td>
</tr>
<tr>
<td>Surgical clips defining TB</td>
<td></td>
</tr>
<tr>
<td>Clips</td>
<td>79</td>
</tr>
<tr>
<td>No clips</td>
<td>45</td>
</tr>
<tr>
<td>$p = 0.05$</td>
<td></td>
</tr>
</tbody>
</table>

NIBB = noninvasive image-guided breast brachytherapy; TB = tumor bed.

![Fig. 2. (a) Posteriorly located tumor bed abutting the chest wall as marked by surgical clips (arrows) on CT simulation. (b) AccuBoost imaging showing the entire tumor bed encompassed within the treatment applicator, including surgical clips (arrows) that abutted the chest wall.](image-url)
compression process, we have found that breast immobilization can be achieved without causing pain. As such, we have found that inability to tolerate NIBB is a rare event as well.

In this study, we found that breast size significantly correlates with eligibility for NIBB. Patients with a very small breast size are not good candidates for NIBB boost as it can be a challenge to achieve breast compression and immobilization. These patients conversely are excellent candidates for treatment with en face electrons. These patients are less susceptible to inaccuracy from daily setup and breast motion. They can be treated with low-energy electrons with conformal coverage of the TB with good sparing of nontarget structures. On the contrary, patients with large breast are more likely to be good candidates for NIBB boost, and it is these patients who benefit most from immobilization and precision treatment achieved with NIBB.

TB location can pose a challenge for positioning the TB on the localization grid. In this study, TBs that were located in the central breast or upper outer quadrant were more likely to be eligible for NIBB boost than those located in the lower or inner quadrants. This trend did not meet statistical significance with a \( p \)-value of 0.07. A posteriorly located TB abutting the chest wall can also be a challenge for NIBB. However, most patients (73%) were still candidates, and there was no statistically significant difference for a nonposterior location. Figure 2 shows an example of a posteriorly located TB that was successfully treated with NIBB boost.

To accurately target the TB, the TB needs to be clearly defined. Surgical clips placed at the time of lumpectomy can help clearly identify the TB (Fig. 3). In this study, only 45% of patients were eligible for NIBB when surgical clips were not present compared with 79% when clips were present. This finding is not dissimilar from studies evaluating CT-based 3D planning for breast boost using external beam electrons or photons. Roughly 50% of TBs are at least in part not clearly defined by postsurgical changes alone using CT imaging (10, 15). It has therefore been recommended by several investigators to use surgical clips as a means to increase the accuracy of identifying the TB when using CT-based 3D planning techniques (10, 16–19).

This study has several limitations. The small sample size precludes identification of factors that may result in smaller difference in likelihood of eligibility for NIBB. Likewise, uncommon anatomic, patient, or technical factors that influence eligibility may not be represented in this study. Last, as the eligibility of NIBB is dependent on patient and anatomic factors, difference in patient populations because of ethnic, cultural, and geographic variations may impact the overall rate of eligibility for NIBB boost.

**Conclusion**

NIBB boost is feasible in most patients even for those with a posteriorly located TB. Patients with larger breast size are more likely to be ideal candidates. Surgical clips are helpful in defining the TB for targeting with NIBB as with other techniques for breast boost.

**References**


noninvasive breast brachytherapy for tumor bed boost. *Int J Radiat Oncol Biol Phys* 2012;83:1374–1380.


