A Simple Optimization Method for Multi-Lumen Balloon Breast Brachytherapy

S. Tafon Penn, PhD, and Tianyou Xue, PhD, St. Luke's Hospital & Health Network, Bethlehem, PA

Introduction

Balloon breast brachytherapy such as MammoSite has been used for more than five years. Some patients who could benefit from balloon brachytherapy are excluded due to proximity of skin to lumpectomy cavity. Of those treated with MammoSite, some have noticeable damage in the ribs on follow up MRI images, which may be due to high rib dose. Recently, Multi-Lumen Balloon (MLB) applicators have been used clinically. We have developed a simple optimization method for MLB breast brachytherapy to reduce high skin and rib dose, and compared treatment plans from this method with traditional single dwell position (SP) treatment plans.

Method and Materials

CT of 16 patients with inflated SenoRx ConturaTM MLB applicators was obtained, and sent to Varian Eclipse HDR planning system. Following the NSABP B-39/RTOG 0413 protocol, 1 cm outside the balloon is contoured as PTV. Following the guidelines of SenoRx, volume within 5 mm of skin and lung is auto contoured as Body_Wall, PTV minus Body_Wall gives the PTV_EVAL, which is similar to the definition of the protocol. We then introduced a PTV_and_Wall volume delineated as the intersection of Body_Wall with the PTV. All dwell positions in all lumen inside the balloon are activated, treatment plan is developed by running optimization with the objectives shown in Table 1.

Table 1. MLB plan objectives for optimization.

ROI	Limit	Volume (%)	Dose (cGy)	Priority
PTV_EVAL	lower	99	3400	100
PTV_EVAL	upper	50	4300	50
PTV_EVAL	upper	5	6500	50
PTV_and_Wall	upper	1	4000	50

For each patient, we also have a plan with single dwell position at the center of the balloon. Minimum distances to skin and ribs, maximum dose to skin and rib, and some DVH values of PTV_EVAL and PTV_and_Wall are studied and compared. Intuitively, the difference between MLB plan and SP plan increase with the increase of the volume of PTV_and_Wall. We use the ratio of PTV_and_Wall over PTV_EVAL as a parameter of some comparison studies.

Results

Figure 1 is a MLB plan which shows reduced skin and chest wall dose. ***Figure 2*** shows the maximum skin dose versus minimum skin distance for both MLB and SP plans. For patients with minimum skin distance of 15 mm or less, SP plans give mean maximum skin dose of 3417 cGy with a range from 2500 cGy to 4500 cGy, while MLB plans give mean maximum skin dose of 2934 cGy with a range from 2300 cGy to 3400 cGy.

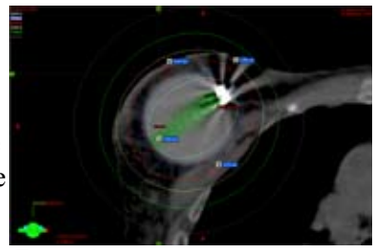

Figure 1.

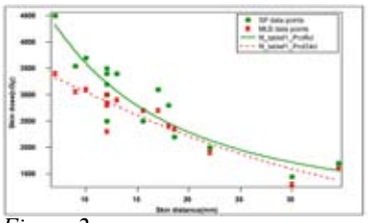

Figure 2.

Figure 3 shows the maximum rib dose versus minimum rib distance for both MLB and SP plans. For patients with minimum rib distance of 5 mm or less, SP plans give mean maximum rib dose of 5950 cGy with a range from 4500 cGy to 7000 cGy, while MLB plans give mean maximum rib dose of 4613 cGy with a range from 4300 cGy to 5000 cGy.

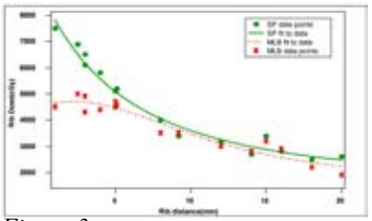

Figure 3.

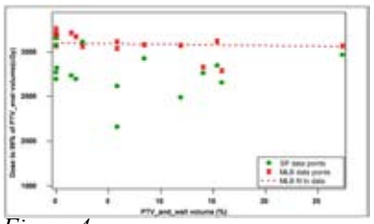

Figure 4.

Figure 4 is a plot of dose to 99% of PTV_EVAL for both MLB and SP plans, which shows that MLB plans always have a high dose to the 99% of PTV_EVAL. The mean dose to 99% of PTV_EVAL is 3073 cGy for MLB vs 2790 cGy for SP.

Figure 5 is a plot of the percentage of PTV_EVAL received 150% of prescribed dose for both MLB and SP plans. For SP plans, the mean PTV_EVAL volume receives at least 150% of dose is 31.6% with a range from 22% to 47.8 %, the mean PTV_EVAL volume receives at least 200% of dose is 5.2% with a range from 1% to 12%; For MLB plans, the mean PTV_EVAL volume receives at least 150% of dose is 31.8% with a range from 28.2% to 38.9 %, the mean PTV_EVAL volume receives at least 200% of dose is 6.4% with a range from 1% to 14.8%.

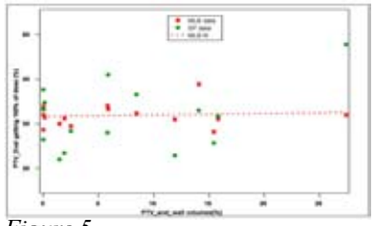

Figure 5.

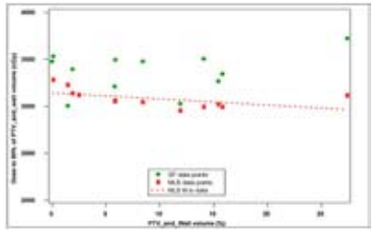

Figure 6.

Figure 6 is a plot of dose to 90% of PTV_and_Wall for both MLB and SP plans. From ***Figure 7***, which shows the PTV_and_Wall volume receive 150% of dose, one can see MLB plans are better if PTV_and_Wall is more than 5% of PTV_EVAL.

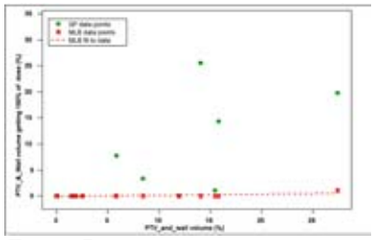

Figure 7.

Conclusion

We have developed a simple optimization method for MLB breast brachytherapy. The MLB plans always have better coverage to PTV_EVAL; reduce maximum skin dose for patients with minimum skin distance of 15 mm or less; reduce maximum rib dose dramatically for patients with minimum rib distance of 5 mm or less, which account for about 50% of patients studied. MLB plans have comparable high dose (150% and 200%) volume as SP plans.