Dosimetric analysis of left breast DIBH VMAT plans comparing sequential and SIB techniques

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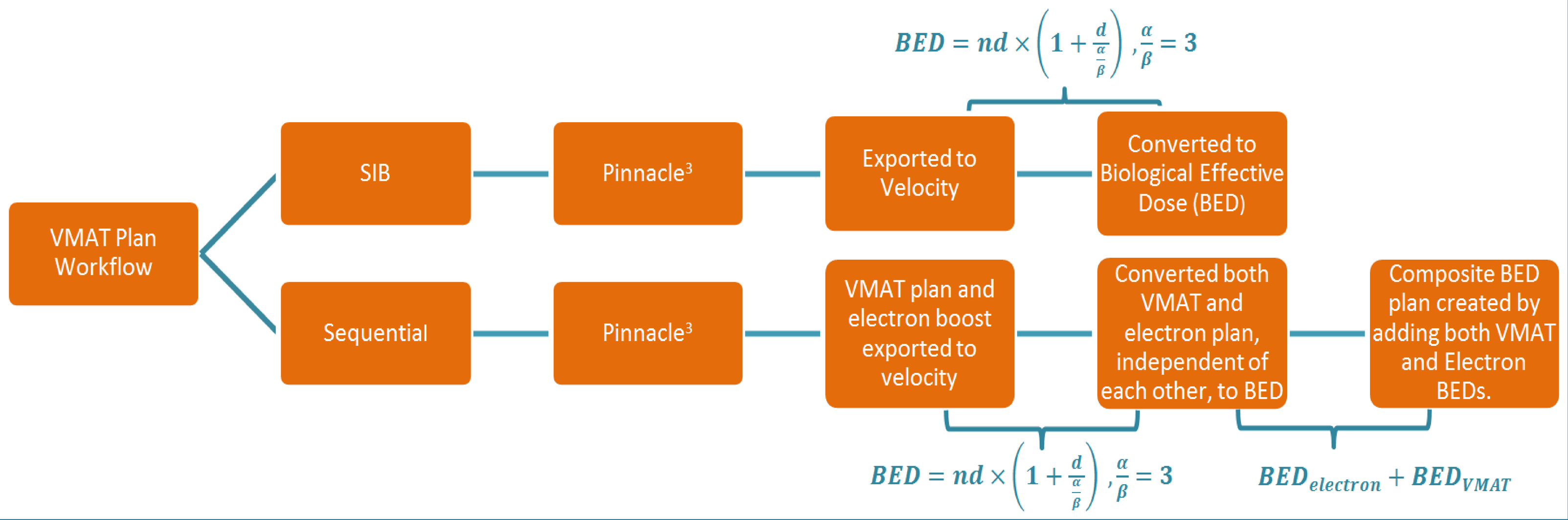
Introduction

For many years the standard of care for adjuvant radiation therapy in women undergoing breast conservation surgery has involved treatment of the involved breast using 3D conformal tangents with an optional electron boost delivered sequentially to the surgical cavity. The use of a simultaneous integrated boost (SIB) to the lumpectomy cavity with hypofractionation provides an attractive opportunity to compress the treatment schedule. To date, the optimal technique for delivering a surgical cavity boost in the setting of a Deep Inspiration Breath Hold (DIBH) has yet to be determined. The purpose of this study is to dosimetrically compare DIBH Volumetric Modulated Arc Therapy (VMAT) using a simultaneous integrated boost vs. a sequential boost to determine the most effective treatment delivery technique.

Materials and Methods

Six (n=6) patients with left sided breast tumors and varying lumpectomy cavity sites were retrospectively planned using the Pinnacle3 TPS. Two DIBH VMAT plans were generated for each patient, one with a sequential electron boost and the other with a simultaneous integrated boost using photons to treat the breast planning target volume (PTV) and lumpectomy PTV as described in RTOG 1005 (see Figure 2.). The VMAT sequential plans used a dose fractionation scheme of 50Gy in 25 fractions to the breast PTV with a sequential 12Gy in 6 fractions electron boost to the lumpectomy PTV, while the VMAT SIB plans treated the breast PTV to 40Gy in 15 fractions with an additional 8Gy to the lumpectomy PTV to a total dose of 48Gy in 15 fractions. Plans were optimized using three coplanar arcs with identical beam parameters between plans and normalized such that 95% of the PTV received 95% of the prescription dose. Plans were evaluated for PTV and organ at risk (OAR) parameters for the lungs, heart, and contralateral breast. For the PTV and OARs, the mean biologically effective dose (BED), volumetric data at fixed BEDs, and the target volume conformity (CI, 95% prescription isodose to 100% target volume) were evaluated in Velocity (see Figure 1.).



Conclusion

This study evaluated the dosimetric differences between DIBH VMAT sequential boost and DIBH VMAT SIB plans. Based on our results, from a dosimetric standpoint VMAT SIB provides a potential alternative to VMAT with a sequential electron boost and is associated with better OAR sparing, comparable PTV coverage, and would allow patients to complete treatment in a shorter amount of time.

Results

For the PTV, there was no statistically significant differences in the conformity index, but statistically significant differences (p<0.05) were observed in the mean BEDs with average values of 90.6Gy vs. 81.9Gy for the breast PTV (VMAT sequential vs. VMAT SIB) and 106.2Gy vs. 102.3Gy for the lumpectomy PTV (VMAT sequential vs. VMAT SIB, see Figure 4.). However, the BED calculations (with α/β =3 Gy) here are not true representations of the biological effect to the targets or the tumor control probability. Regarding the OARs, statistically significant differences were observed between the two plans for the heart and left lung dose. With the use of SIB, the left lung showed a 6.2% reduction in the volume that received a BED of 20Gy and a 34.2% reduction in the mean BED, while the heart showed a 47.2% reduction in the mean BED when compared to the sequential plans (see Figure 3.).

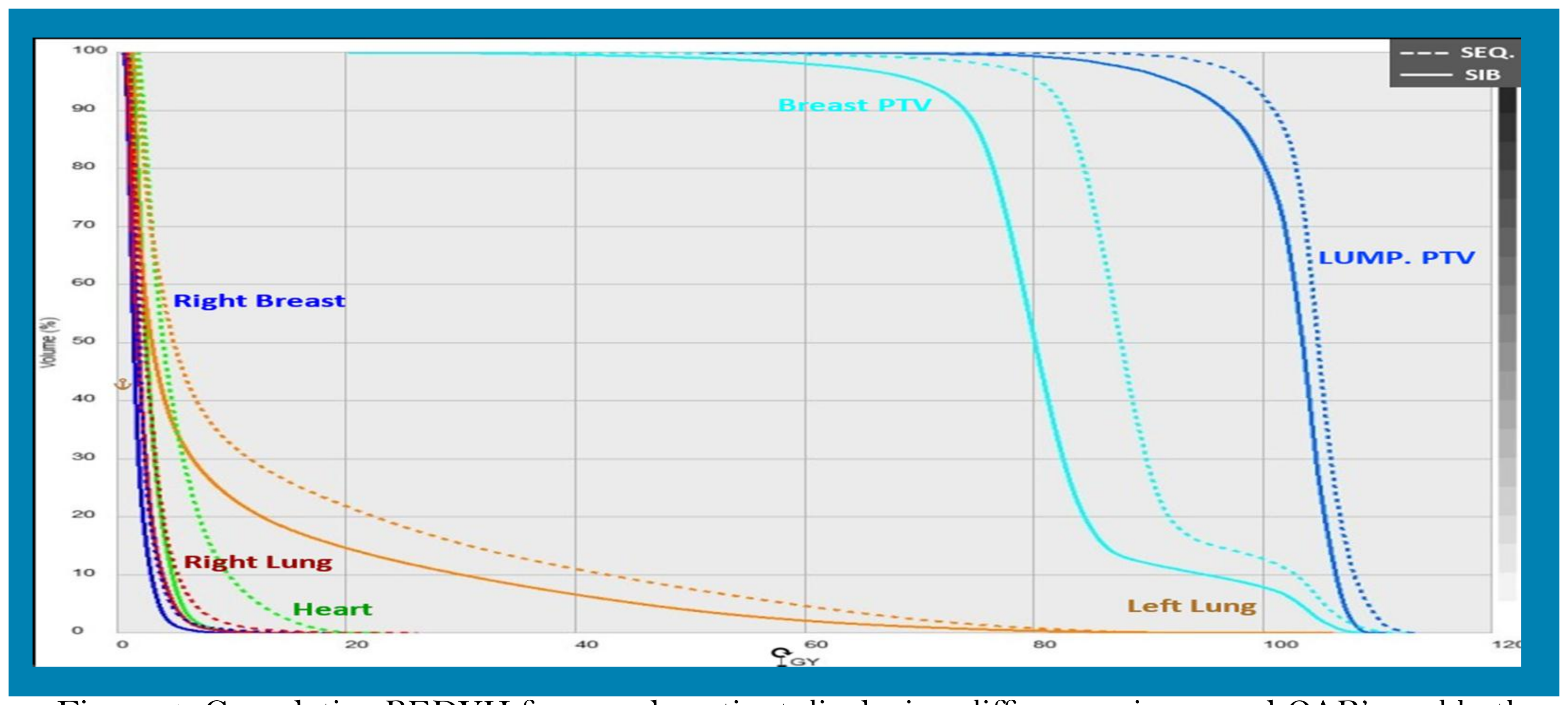


Figure 1. Cumulative BEDVH for sample patient displaying differences in several OAR's and both PTV's

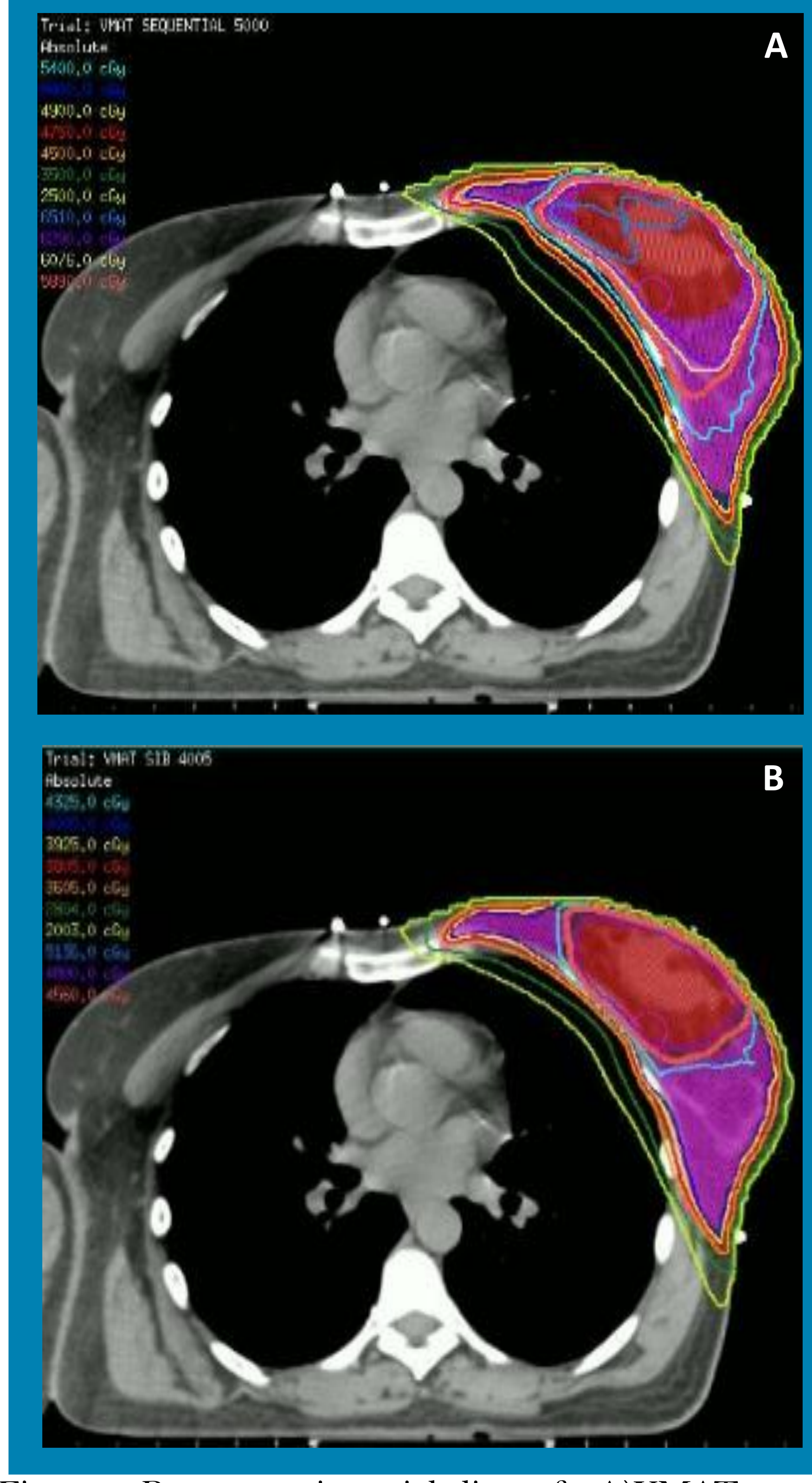


Figure 2. Representative axial slices of A)VMAT sequential and B)VMAT SIB plans planned using the Pinnacle TPS.

Patient Number	Left Lung				Right Lung		Heart				Contralateral Breast	
	BED of 20 Gy		*Mean BED (Gy)*		*Mean BED (Gy)*		*BED of 5 Gy*		*Mean BED (Gy)*		*Mean BED (Gy)*	
Plan	**Seq.**	**SIB**	**Seq.**	**SIB**	**Seq.**	**SIB**	**Seq.**	**SIB**	**Seq.**	**SIB**	**Seq.**	**SIB**
1	21.24%	13.53%	13.27	9.03	3.23	1.51	35.54%	6.21%	5.30	2.94	3.20	2.17
2	21.12%	15.07%	13.90	10.10	2.48	2.34	18.80%	9.67%	3.59	2.95	2.88	1.57
3	22.86%	17.08%	14.66	10.65	2.38	1.84	37.59%	8.89%	5.04	3.24	2.43	1.62
4	21.54%	14.66%	14.20	9.24	1.81	2.03	35.13%	4.82%	4.96	2.73	1.47	1.98
5	21.83%	14.65%	13.84	9.69	3.06	2.30	38.19%	9.06%	5.22	2.99	2.38	1.80
6	18.09%	14.22%	11.64	8.93	2.26	1.24	13.74%	6.59%	3.35	2.68	1.88	1.74
p-value	**<0.01**		**<0.01**		**0.06**		**<.01**		**<.01**		**0.09**	

Figure 3. Dosimetric comparison of OAR's for the VMAT sequential and VMAT SIB plans.

Patient Number	Breast PTV				Lumpectomy PTV			
	Mean BED (Gy)		*Conformity Index*		*Mean BED (Gy)*		*Conformity Index*	
Plan	**Seq.**	**SIB**	**Seq.**	**SIB**	**Seq.**	**SIB**	**Seq.**	**SIB**
1	89.42	81.21	0.97	0.97	104.37	102.33	0.98	0.99
2	90.86	81.97	0.97	0.97	107.30	102.29	0.99	0.99
3	91.35	82.45	0.95	0.96	106.56	102.31	0.99	0.99
4	93.25	82.84	0.95	0.96	108.53	102.28	0.99	0.99
5	89.09	81.35	0.97	0.95	104.54	102.22	0.98	0.96
6	89.46	81.79	0.98	0.99	106.04	102.23	1.00	0.99
p-value	**<.001**		**0.97**		**0.001**		**0.26**	

Figure 4. Dosimetric comparison of PTV's for the VMAT sequential and VMAT SIB plans. (CI= conformity index, 95% isodose to 100% target volume)

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