Comparing SBRT Lung Treatment Plans Using Acuros and AAA to Evaluate Dosimetric Guidelines

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INTRODUCTION

Since its release, Acuros has been gaining more use clinically. However, many institutions have been hesitant to implement it. This is partly because current clinical practices and outcomes are based around collapsed cone and convolution algorithms. The higher accuracy calculations of Acuros result in a change in dose distributions, especially in heterogeneous regions like the lungs. The increased accuracy's usefulness is currently limited by how readily it can be applied to clinical guidelines and protocols. In general, planning in Acuros has made it more challenging to meet clinical criteria. The aim of this study is to compare Acuros to AAA for SBRT lung patients in order to address this issue and help develop new clinical guidelines.

AIM

Clinical trials for SBRT lung treatments have been developed using convolution-superposition and collapsed cone convolution algorithms, such as AAA. However, more accurate algorithms have become commercially available and are gaining use clinically. Acuros has rapidly been adopted as one of the more accurate algorithms. The increased accuracy is especially evident in heterogeneous regions, such as the lung. This difference is the most pronounced for island-type tumors. The aim of this study is to evaluate SBRT lung planning using AXB compared to AAA and determine how to apply the older protocols to AXB.

METHOD

Two treatment techniques were analyzed using RTOG 0813 criteria. First, prior to the adoption of Acuros in our clinic, modulated conformal arcs were used with AAA. These plans have been recalculated in Acuros. Second, after the adoption of Acuros, it became necessary to add static oblique beams to help achieve dose conformality limits. These plans have been re-calculated in AAA. Both cases were calculated with the original MU as well as renormalized to 95% PTV coverage. The former was done to directly compare results for biological impact, while the renormalization allows for a dosimetric comparison of potential plan quality. All plans were first optimized to meet ROI constraints (CW: V30Gy < 30mL; Lung: V20Gy<10%).

A cohort of 30 patients treated with plans calculated by AXB was retrospectively analyzed. The delivered plans were recalculated using AAA with two treatment techniques. The first case was done with modulated conformal arc beams only. The second used the same conformal arcs, but had 1-3 static oblique beams added to help achieve protocol recommendations. A subgroup of 13 patients with island-type tumors were evaluated separately. The plans were evaluated using the RTOG 0813 guidelines.

RESULTS

As Table 1 shows, while keeping the MU equal, Acuros yields a greater max dose, but all other doses related to the other dosimetric properties decreased by a few percent. The additional static beams reduced this effect a little. These effects were more pronounced for island-type tumors than the overall average. Plans, which were optimized in AAA and recomputed in Acuros had a reduced coverage from 95% to 91.4% and 88.5% overall and for island-type tumors, respectively. These plans more easily met the protocol guidelines, but at the cost of reported PTV coverage. Conversely, when plans were optimized in Acuros and recalculated in AAA, tumor coverage increased from 95% to 96.6% and 97.4% for all PTVs and island-type PTVs, respectively, despite a 2% drop in PTV max in both cases. In addition, V105, conformality index (CI), D2CM, and V50 all increased by an appreciable amount. The number of total minor deviations from V105, CI, and D2cm in increased from 5 to 29 in AAA.

In order achieve equal PTV coverage of V95 = 100% Rx AXB required 2% more MU, on average. When comparing AAA to AXB using the same MU, this lead to AXB having worse tumor coverage (V100=95.0% vs 91.4%) Due to the decrease in dose, AXB reported better results in maximum dose, high dose spillage, D2cm, and V50. When the plans were renormalized to match PTV coverage, AXB did worse in all RTOG evaluation criteria. These results were more extreme for island-type tumors.

When normalized to 95% PTV coverage, plans in AXB had raw doses increase for all other dosimetric values, relative to the normalized AAA plans. This is especially true with island-type tumors. Therefore treatment planners using AXB will have a harder time meeting protocol constraints. A direct comparison of the two beam arrangements is the subject of a separate submission.

Site	Beams	Model	Model MU*	V100 (PTV)	Dmin (PTV)	Dmax (PTV)	V105 (%PTV)	CI (%PTV)	D2CM (%PTV)	V50 (%PTV)	V105 Minor	CI Minor	D2cm Minor	V50 Minor	V50 Major	MU
All	Arcs and Obliques	AXB	AXB	95.0%	90.0%	124.4%	8.2%	114.4%	96.9%	512.5%	0	1	4	19	5	2166.4
		AAA	AXB	96.6%	92.8%	122.8%	10.9%	120.4%	98.7%	513.7%	8	13	8	21	4	2166.4
		AAA	AAA	95.0%	91.1%	120.7%	6.2%	112.2%	96.8%	495.0%	1	5	5	22	2	2112.3
	Arcs Only	AXB	AAA	91.4%	88.4%	121.5%	5.4%	107.4%	98.8%	503.5%	0	6	14	22	2	2115.0
		AAA	AAA	95.0%	90.5%	120.5%	6.3%	114.6%	100.4%	508.0%	0	7	18	24	2	2115.0
		AXB	AXB	95.0%	89.9%	123.4%	7.6%	115.5%	100.4%	522.0%	0	8	15	18	7	2154.3
Island	Arcs and Obliques	AXB	AXB	95.0%	89.8%	128.1%	7.2%	113.0%	97.5%	539.0%	0	0	3	8	4	2395.5
		AAA	AXB	97.4%	93.8%	126.1%	10.7%	121.6%	99.0%	536.8%	4	5	2	9	3	2395.5
		AAA	AAA	95.0%	91.1%	122.4%	3.1%	108.6%	95.7%	507.8%	0	0	2	9	2	2305.1
	Arcs Only	AXB	AAA	88.5%	87.4%	123.5%	3.3%	100.3%	99.9%	521.0%	0	1	8	10	1	2301.0
		AAA	AAA	95.0%	90.4%	122.3%	3.8%	110.4%	101.1%	525.5%	0	0	9	12	1	2301.0
		AXB	AXB	95.0%	89.9%	127.1%	7.4%	114.6%	102.9%	555.1%	0	3	9	6	6	2374.2

*Table 1: Acuros vs. AAA dosimetric comparison average over 30 total and 13 island-type patients. V100, V90, Dmin, and Dmax are percent of prescribed dose. V105, CI, D2cm, and V50 are percent of PTV volume. Minor and Major refer to deviations from RTOG 0813 protocol guidelines. *Model MU refers to which algorithm was used to normalize the plan*

CONCLUSIONS

By switching over to a more accurate dose calculation algorithm, more MU are needed for PTV coverage and it is more difficult to achieve RTOG protocol guidelines upon renormalization. These issues are especially apparent in island-type tumors. The addition of static, oblique, beams has helped to mitigate these issues, but does not resolve them. New guidelines regarding acceptable dose to the PTV and healthy tissues are recommended for lung treatments using Acuros XB. .

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