JULY 12–16
2020 VIRTUAL
JOINT AAPM | COMP MEETING
EASTERN TIME [GMT-4]

Are all volumes of brain metastases suitable for Linac-based Stereotactic Radiosurgery?

C. Liu, S. Ahmed, T. Ma, Y. Cho, G. Neyman, J. Suh, and P. Xia

Department of Radiation Oncology, Cleveland Clinic, Cleveland OH, USA

Cleveland Clinic

INTRODUCTION

Linac-based stereotactic radiosurgery (SRS) for multiple brain metastases is gaining popularity because of volumetric modulated arc therapy (VMAT). A high degree of modulations in VMAT allows optimal dose conformity and sparing of organs-at-risk, producing similar plan quality as Gamma Knife (GK).[1,2]

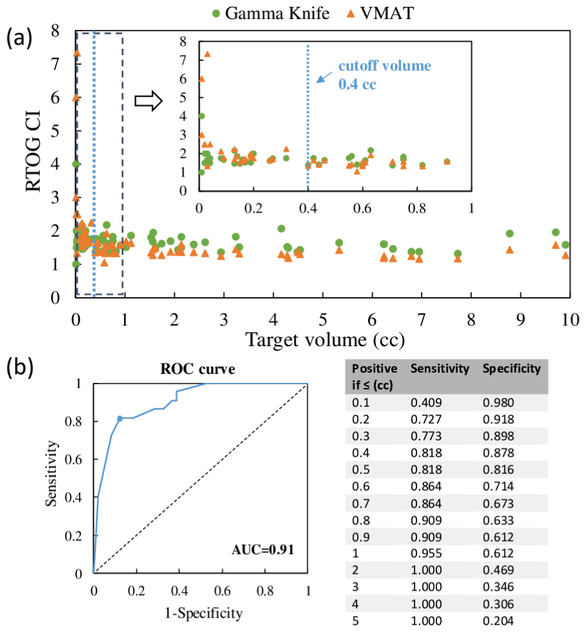
AIM

The purpose of this study is to investigate whether there is a limit of target volume below which VMAT-based SRS may not be suitable.

METHOD

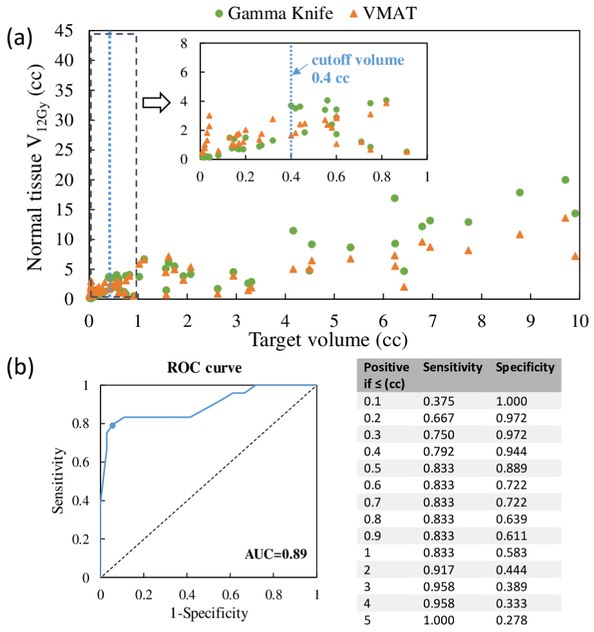
- Twenty six patients with 2-3 brain metastases per patient previously treated with GK were re-planned using VMAT.
- A total of 76 targets with a median target volume of 0.75 cc (range: 0.01-17.68 cc).
- Prescription dose varying from 11-24 Gy.
- Single- or two-isocenter, multiple non-coplanar dynamic arcs in a 6MV flattening filter free mode with high-definition multileaf collimator (HD-120 MLC).
- All plans had >99% of each tumor volume receiving the prescription dose.
- Plan quality was evaluated based on RTOG conformity index (CI), Paddick gradient index (GI), normal tissue V_{12Gy} and $V_{4.5Gy}$.
- Receiver operating characteristic (ROC) curves associated with RTOG CI and normal tissue V_{12Gy} were employed to probe the cutoff target volume above which VMAT generated superior plans to GK.
- Wilcoxon signed rank test was used to compare the plan quality between GK and VMAT.

RESULTS



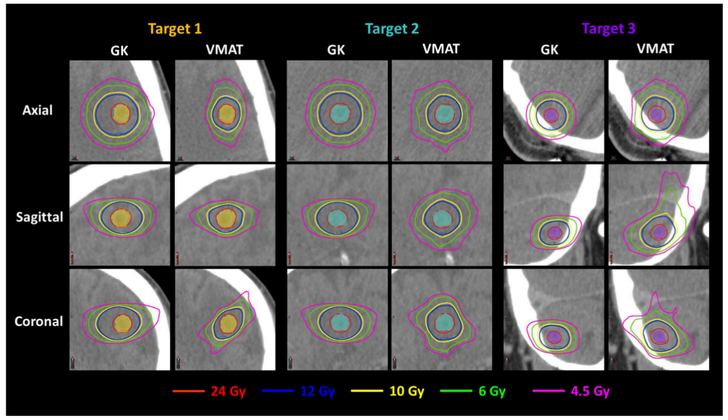
Positive if ≤ (cc)	Sensitivity	Specificity
0.1	0.409	0.980
0.2	0.727	0.918
0.3	0.773	0.898
0.4	0.818	0.878
0.5	0.818	0.816
0.6	0.864	0.714
0.7	0.864	0.673
0.8	0.909	0.633
0.9	0.909	0.612
1	0.955	0.612
2	1.000	0.469
3	1.000	0.346
4	1.000	0.306
5	1.000	0.204

Figure 1 (a) RTOG CI as a function of target volume for GK and VMAT plans. The insert shows an enlarged view of target volumes between 0 and 1 with a cut-off volume of 0.4 cc. (b) ROC curve associated with RTOG CI and a table of statistics for selected thresholds. The cutoff volume of 0.4 cc corresponds to the blue dot on the ROC curve.



Positive if ≤ (cc)	Sensitivity	Specificity
0.1	0.375	1.000
0.2	0.667	0.972
0.3	0.750	0.972
0.4	0.792	0.944
0.5	0.833	0.889
0.6	0.833	0.722
0.7	0.833	0.722
0.8	0.833	0.639
0.9	0.833	0.611
1	0.833	0.583
2	0.917	0.444
3	0.958	0.389
4	0.958	0.333
5	1.000	0.278

Figure 2 (a) Normal tissue V_{12Gy} as a function of target volume for GK and VMAT plans. The insert shows an enlarged view of target volumes between 0 and 1 with a cut-off volume of 0.4 cc. (b) ROC curve associated with normal tissue V_{12Gy} and a table of statistics for selected thresholds. The cutoff volume of 0.4 cc corresponds to the blue dot on the ROC curve.



	Target 1		Target 2		Target 3	
	GK	VMAT	GK	VMAT	GK	VMAT
RTOG CI	1.38	1.35	1.41	1.39	1.46	2.85
NT V_{12Gy} (cc)	3.7	1.64	3.62	2.41	1.49	2.28
GI	7.45	3.78	6.55	4.70	8.53	6.51
$V_{4.5Gy}$ (cc)	17.2	10.47	16.70	15.94	7.29	16.26

Figure 3 Representative isodose distribution and plan quality comparison between GK and VMAT plans for patient with three targets. Target volumes for Target 1, Target 2 and Target 3 are 0.40 cc, 0.44 cc and 0.13 cc, respectively. Prescription was 24 Gy for all targets. Two-isocenter technique was used for the VMAT plan, where Target 1 was associated with one isocenter and the other isocenter was placed at the geometric center of Target 2 and Target 3.

CONCLUSIONS

Target volumes greater than 0.4 cc may be suitable for VMAT-based SRS with improved conformity and normal brain sparing while for volumes smaller than 0.4 cc, GK plans can be considered for achieving better overall plan quality.

	Target <0.4 cc			Target >0.4 cc		
	GK	VMAT	p	GK	VMAT	p
RTOG CI	1.68	1.85	<0.05	1.59	1.36	<0.05
NT V_{12Gy} (cc)	0.70	1.25	<0.05	3.87	3.04	<0.05
GI	3.75	6.62	<0.05	3.19	3.30	>0.05
$V_{4.5Gy}$ (cc)	2.58	6.82	<0.05	17.55	16.04	<0.05

Table 1 Statistical comparison of plan quality endpoints between GK and VMAT plans. Median value was shown.

REFERENCES

1. **Thomas EM et al.** Plan quality and treatment planning technique for single isocenter cranial radiosurgery with volumetric modulated arc therapy. *Pract Radiat Oncol 2012;2:306-313*
2. **Liu H et al.** Plan Quality and Treatment Efficiency for Radiosurgery to Multiple Brain Metastases: Non-Coplanar RapidArc vs. Gamma Knife. *Front oncol 2016;6:26*

ACKNOWLEDGEMENTS

CL is supported by AVO and JS and PX received a research grant from AVO.

CONTACT INFORMATION

Ping Xia, xiap@ccf.org