Comparison of two craniospinal irradiation techniques and evaluating low dose to critical structures

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Introduction

Craniospinal irradiation (CSI) treats the whole brain, spinal canal, and the at-risk cerebrospinal fluid compartments. For adults, the spinal canal requires two junction area, dividing the spine into an upper and lower spine.[1] The large treatment area raises concern of radiation-induced complications.

Purpose

The retrospective study evaluates the feasibility and dose to critical structures of two CSI planning techniques.

Methods

- 2 patient datasets
- Pinnacle – Phillips version 9.10
- Beam energy: 6 MV
- All plans optimized to meet Banner MD Anderson clinical goals:
  - PTV: V100 > 95% or 90%
  - PTV 95 (junction areas): V95 > 95% or 90%

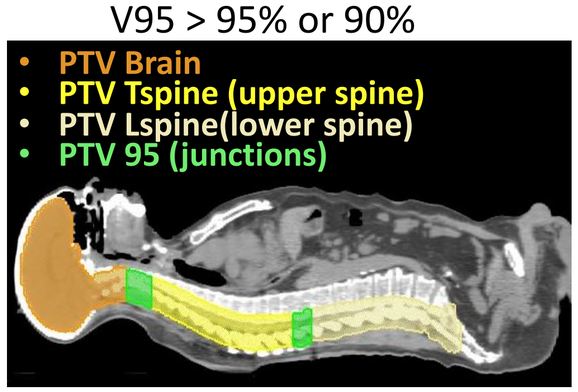

Figure 1. Patient A planning target volumes (PTVs).

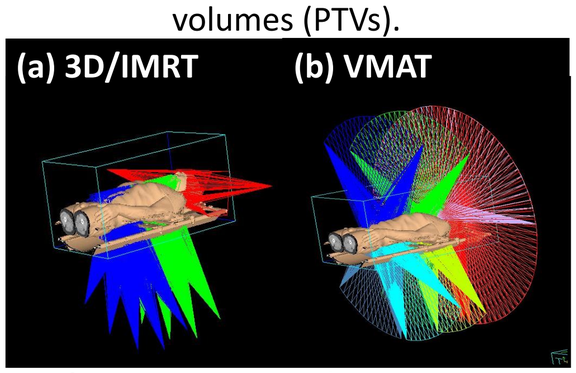

Figure 2. Patient A beams setup.

Methods

- Technique 1: 3D/IMRT
  - 3D forward planning (with step-and-shoot) to the brain.
  - Intensity-modulated radiation therapy (IMRT), step-and-shoot inverse planning, to the spinal canal. Upper spine & lower spine each using 5 posterior beams.
- Technique 2: Volumetric-modulated arc therapy (VMAT)
  - Brain: 2 full arcs & 1 anterior half arc
  - Upper & lower spine: partial arcs of 1 anterior & 2 posterior arcs.

Results

- Overall, the integral dose was lower in the VMAT plans compared to the 3D/IMRT plans, shown in Table 1 and Figure 3. In Patient A, the thyroid has a higher mean dose of +232.7 cGy using VMAT.
- Both plans are optimized to meet clinical goals of the PTVs. Adequate coverage can be seen in the sagittal view of Figure 4. The low dose (468 cGy) scatters more anteriorly in the VMAT plan.
- The 3D/IMRT total monitor units (MU) are lower. The VMAT total beams-on time are shorter. The VMAT quality assurance (QA) passing percentage are higher. Table 2 displays these values.

	Patient A			Patient B		
OAR	3D/IMRT	VMAT	% Diff.	3D/IMRT	VMAT	% Diff.
	D_{max} (cGy)			D_{max} (cGy)		
Right Lens	2212.2	420.5	-81%	466.3	330.6	-29%
Left Lens	1478.4	447.3	-70%	497.0	330.6	-33%
	D_{mean} (cGy)			D_{mean} (cGy)		
Heart	690.9	487.3	-29%	802.5	640.7	-20%
Thyroid	1390.5	1623.2	+17%	1711.6	1235.2	-28%
Pelvis Bone	746.1	724.9	-3%	585.9	514.3	-12%
Right Lacrimal	1676.2	517.2	-69%	1748.3	871.3	-50%
Left Lacrimal	1485.4	611.3	-59%	2030.9	1207.7	-41%
Right Kidney	344.6	390.0	+13%	512.4	479.7	-6%
Left Kidney	254.1	124.6	-51%	516.8	450.4	-13%
	V_{5Gy}			V_{5Gy}		
Lungs	29.19%	27.02%	-7%	45.89%	44.53%	-3%

Table 1. Organs-at-risk (OAR) dose and the percent differences (% Diff.) of the VMAT from the 3D/IMRT.

	Modality	Total MU	Total Beams-On Time (mins:secs)	Average QA passing % of Tx sites
Patient A	3D/IMRT	971	8:52	85%
	VMAT	1547	7:16	92%
Patient B	3D/IMRT	802	8:00	91%
	VMAT	1306	7:13	97%

Table 2. Total monitor units (MU), total beams-on time (minutes:seconds), and average quality assurance (QA) passing percentage of treatment (Tx) sites.

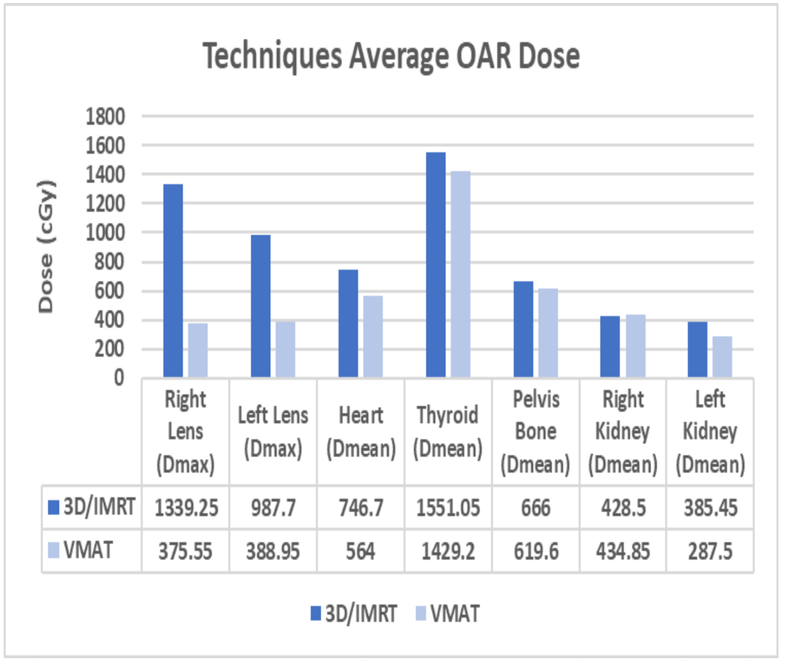

Figure 3. Comparison of average OAR doses of each technique.

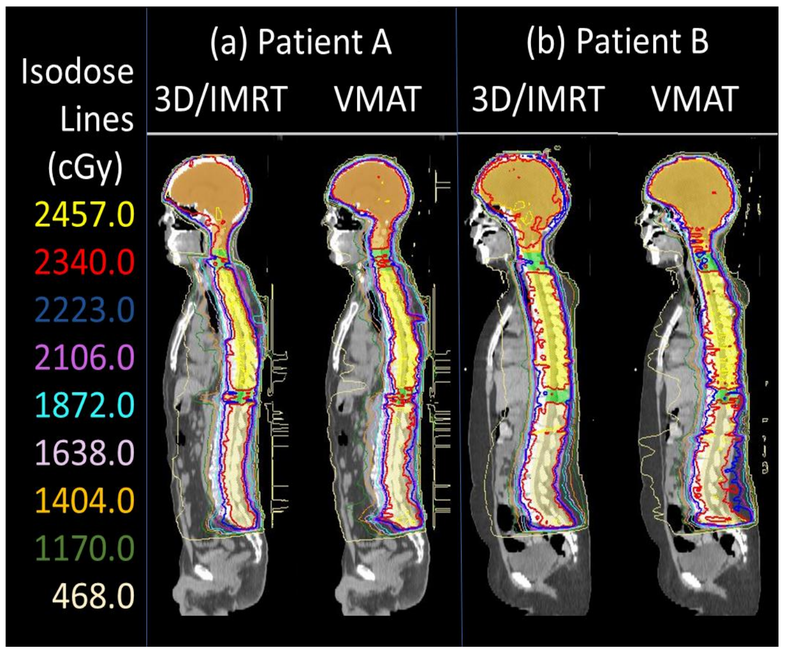

Figure 4. Sagittal view of dose distributions.

Conclusions

- Both techniques are applicable for non-pediatric patients.
- VMAT may be a good option provided to patients to reduce integral dose to critical structures in case of the need for re-irradiation in the future.

References

1. Studenski, M., Shen, X., Yu, Y., Xiao, Y., Shi, W., Biswas, T., Werner-Wasik, M., & Harrison, A. S. (2013). Intensity-modulated radiation therapy and volumetric-modulated arc therapy for adult craniospinal irradiation—A comparison with traditional techniques. *Medical Dosimetry : Official Journal of the American Association of Medical Dosimetrists*, *38*(1), 48–54. https://doi.org/10.1016/j.meddos.2012.05.006