At the University of Wisconsin Hospital and Clinic we have access to TomoTherapy and Varian TrueBeam treatment units. For this assignment, I decided to compare a VMAT plan to a plan using the SupraFireFly technique designated by Palmer.[1] Both plans were created in Pinnacle for our TrueBeam linac. The treatment planning order (TPO) written by the radiation oncologist included the prescription, 1.8 Gy per fraction for 28 fractions to a total of 50.4 Gy, and the desired constraints, which I used to evaluate both plans (Figure 1). The required coverage of the PTV was that 95% received 100% of the prescribed dose. The VMAT plan was created using 2 full arcs. At UW Hospital, we only use static IMRT fields for pulse reduced dose rate (PRDR) cases for re-irradiation, otherwise the technique used is VMAT when the technique indicated by the physician is IMRT on the TPO.

Organ	**Constraint**
Spinal Cord	Max <50 Gy
Lung_L	Mean <23 Gy V_{20} <30%
Lung_R	Mean <23 Gy V_{20} <30%
Heart	Mean <25 Gy
Bilateral Kidneys	2/3 <18 Gy
High risk bowel	0.1 cc <50 Gy

Figure 1. Desired constraints

When comparing the isodose lines, it can be seen that, although there is less 10 Gy (purple isodose line) in the SupraFireFly plan throughout the right side of the patient, there is quite a bit more 30 Gy (green isodose line) splashed along the left side (Figure 2). The conformality of the 50.4 Gy (red isodose line) and 45 Gy (orange isodose line) lines are comparable, though they follow the irregularities of the PTV slightly closer in the VMAT plan. Though the DVHs look very similar, it should be noted that the curves for the spinal cord (SpinalCord) and the left lung (Lung_L) have shifted up and to the right slightly, representing higher doses received by these structures, and that the curve for the right lung (Lung_R) have shifted down and to the left, representing a lower dose received by this structure for the SupraFireFly plan compared to the VMT plan (Figures 2 and 3). This is expected considering all the fields for the SupraFireFly plan is entering through the posterior and left aspects of the patient and the dose from the VMAT beams are being spread throughout the entire body of the patient.

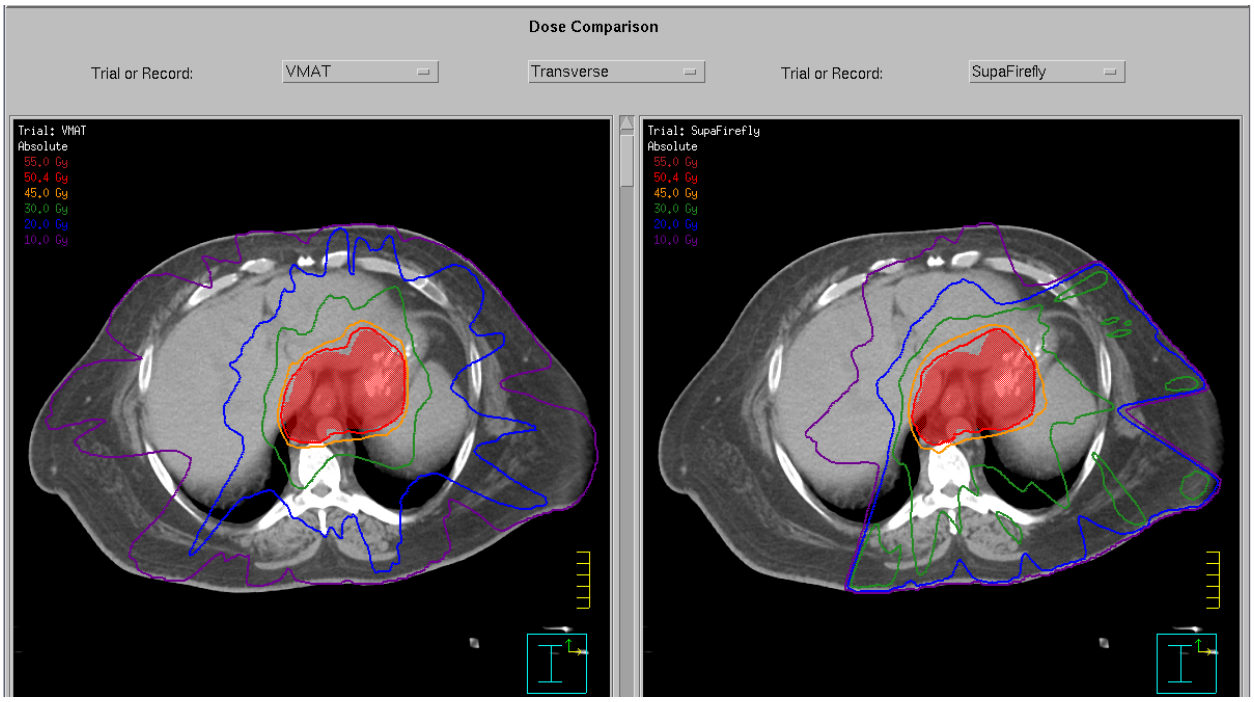
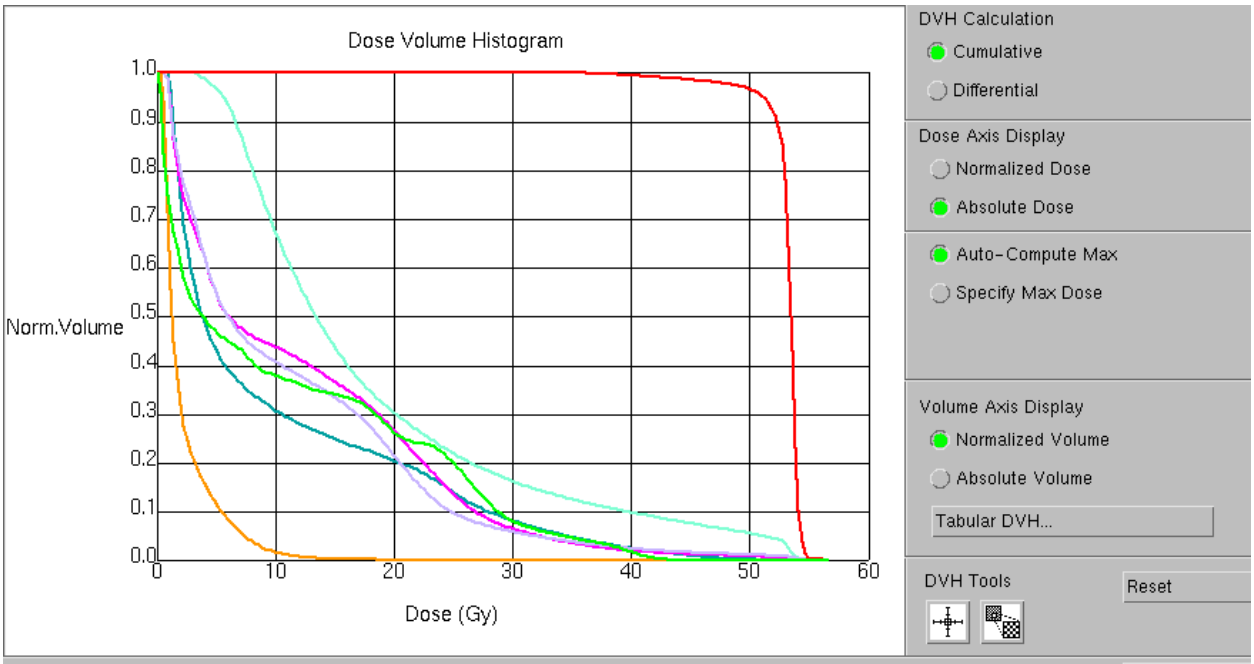


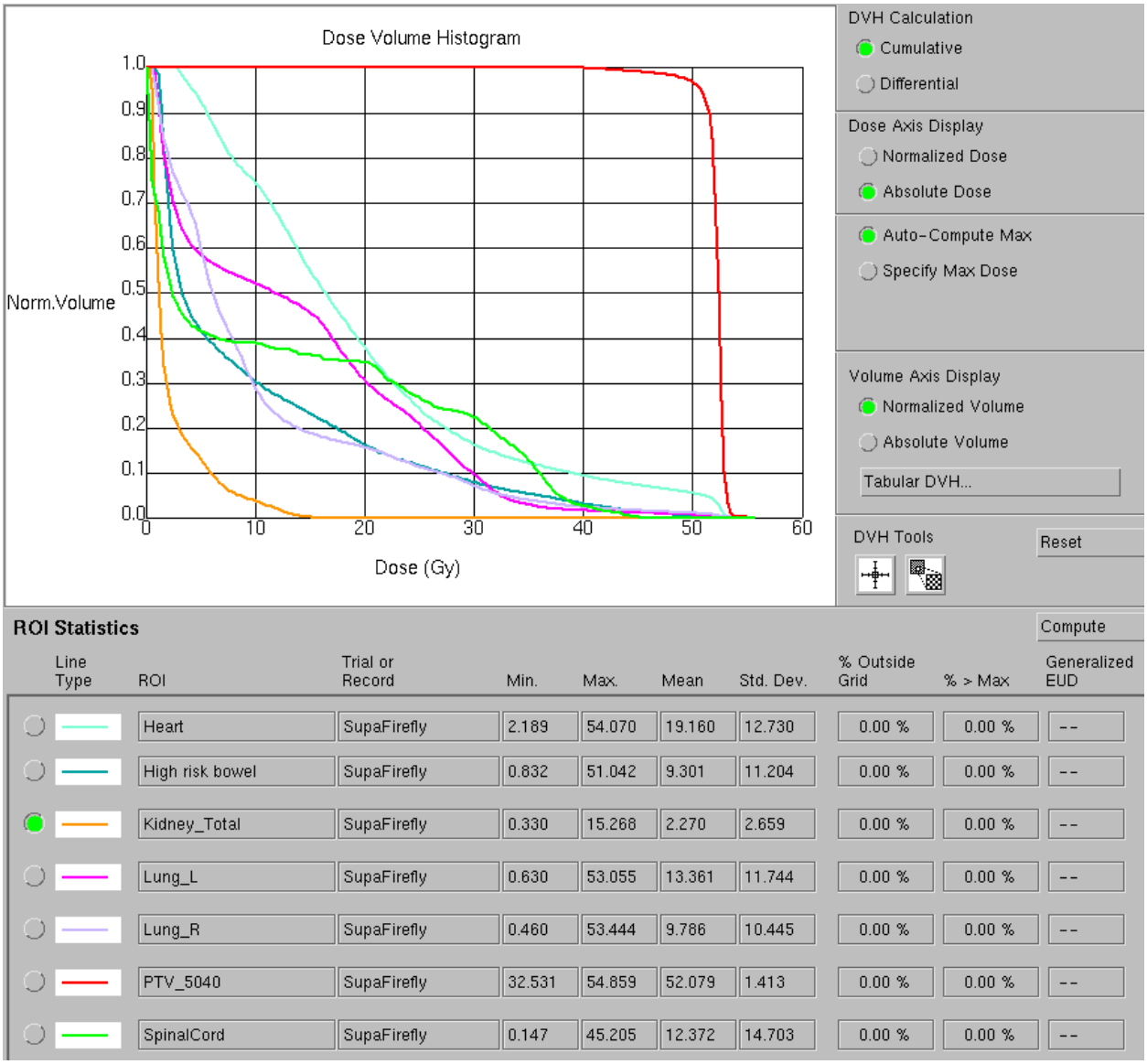
Figure 2. Comparison of isodose lines of the VMAT plan and the SupraFireFly plan. The volume in red is the PTV.



ROI Statistics Compute

Line Type	ROI	Trial or Record	Min.	Max.	Mean	Std. Dev.	% Outside Grid	% > Max	Generalized EUD
	Heart	VMAT	2.644	55.632	18.043	12.970	0.00 %	0.00 %	--
	High risk bowel	VMAT	0.738	50.514	9.763	11.287	0.00 %	0.00 %	--
	Kidney_Total	VMAT	0.346	18.593	2.202	2.298	0.00 %	0.00 %	--
	Lung_L	VMAT	0.686	55.144	11.743	11.218	0.00 %	0.00 %	--
	Lung_R	VMAT	0.671	54.890	11.077	10.877	0.00 %	0.00 %	--
	PTV_5040	VMAT	30.990	56.366	53.049	2.024	0.00 %	0.00 %	--
	SpinalCord	VMAT	0.201	43.132	10.818	12.109	0.00 %	0.00 %	--

Figure 3. Dose Volume Histogram for the VMAT plan



Line Type	ROI	Trial or Record	Min.	Max.	Mean	Std. Dev.	% Outside Grid	% > Max	Generalized EUD
	Heart	SupaFirefly	2.189	54.070	19.160	12.730	0.00 %	0.00 %	--
	High risk bowel	SupaFirefly	0.832	51.042	9.301	11.204	0.00 %	0.00 %	--
	Kidney_Total	SupaFirefly	0.330	15.268	2.270	2.659	0.00 %	0.00 %	--
	Lung_L	SupaFirefly	0.630	53.055	13.361	11.744	0.00 %	0.00 %	--
	Lung_R	SupaFirefly	0.460	53.444	9.786	10.445	0.00 %	0.00 %	--
	PTV_5040	SupaFirefly	32.531	54.859	52.079	1.413	0.00 %	0.00 %	--
	SpinalCord	SupaFirefly	0.147	45.205	12.372	14.703	0.00 %	0.00 %	--

Figure 4. Dose Volume Histogram for the SupraFireFly plan

All of the constraints were met in the VMAT plan whereas the V_{20} <30% constraint for the left lung (Lung_L) and the 0.1 cc <50 Gy constraint for the high risk bowel were the only constraints not met in the SupraFireFly plan, though the left lung was only exceeding the desired constraint by 0.16% and the high risk bowel was 0.2 cc above the desired constraint (Figure 5). A lower max dose for the spinal cord, mean and V_{20} for the left lung, and mean for the heart, and volume of high risk bowel were achieved by the VMAT plan compared to the SupraFireFly plan. The SupraFireFly achieved a lower mean dose and V_{20} for the right lung (Lung_R). Both plans achieved the necessary coverage of 95% of the PTV receiving 100% of the prescribed dose.

Organ	Constraint	VMAT	SupraFireFly
Spinal Cord	Max <50 Gy	43.132 Gy	45.205 Gy
Lung_L	Mean <23 Gy V_{20} <30%	11.743 Gy 26.18%	13.361 Gy 30.16%
Lung_R	Mean <23 Gy V_{20} <30%	11.077Gy 20.98%	9.786 Gy 15.45%
Heart	Mean <25 Gy	18.043 Gy	19.160 Gy
Bilateral Kidneys	2/3 <18 Gy	0%	0%
High risk bowel	0.1 cc <50 Gy	0.04 cc	0.3 cc

Figure 5. Achieved constraints. Values in red did not meet the desired constraint.

After evaluating both plans, I do not believe that the SupraFireFly technique was superior to the VMAT technique, in this particular case, as I do not think that the decreased dose to the right lung outweighed the fact that 2 constraints were not met. This could be due to size and location of the PTV and I would like to try the SupraFireFly technique for various sized target volumes at different levels throughout the esophagus. In looking at the time it would take the deliver each plan, the 2 arc VMAT plan would be significantly shorter than the 7 field static IMRT SupraFireFly plan. Though it was interesting to see the IMRT objectives recommended by Palmer[1], they were very different than the values I typically use when creating IMRT and VMAT plans, so I did not find them extremely helpful. I think that the SupraFireFly technique would be an acceptable option in situations where VMAT was not available or for patients in which it is imperative to decrease dose to the right lung as much as possible. As the static IMRT technique is not common at my internship site, I enjoyed getting to create a plan using the SupraFireFly technique.

Reference

1. Palmer, M. Advancement in treatment planning techniques and technologies for esophagus cancer. [Powerpoint lecture]. MD Anderson cancer center. La Crosse, WI: UW-L Medical Dosimetry Program; 2017.