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The Impact of Beam Selection: 6MV Flattening Filter Free (FFF) vs 6MV Flattening Filter on the Dosimetric Quality and Beam Delivery of Lung and Liver Stereotactic Radiotherapy (SBRT) Treatment Plans.

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ABSTRACT

Purpose:

to evaluate the impact of beam selection: 6MV FFF beams vs 6MV FF on the dosimetric quality of lung and liver SBRT treatment plans, beam on time (BOT) and monitor units (MU).

Methods:

Twenty clinical treatment plans (10 lung and 10 liver SBRT) were developed using 6FFF beams in the Eclipse 16.1 TPS and used to treat patients were retrospectively re planned using 6MV(FF) beams and the same optimization priorities as in the original plans. The 6MV FF plans were normalized to maintain the same PTV coverage as in the 6MVFFF plans. All plans (20 clinical 6MV FFF and 20 re planned6MV FF) were delivered in dry runs using the Elekta versa HD linear accelerator and the actual BOT and dose rates were recorded. The FFF & FF plans were compared in terms of dosimetric parameters (CI, HI, hot spot) and doses to organs at risk (OAR) (for lung plans: lung mean dose and lung V20%, maximum dose to esophagus, heart, spinal cord, chest wall D 50cc and for liver plans: liver-ITV mean dose, liver V0cGy, Rt kidney mean dose, maximum dose to skin, spinal cord and body-PTV). MUs were also compared.

Results:

The CI and HI, hot spot and doses to OARS for both 6MV FFF & 6 MV FF beams were comparable, MU' differences varied from one lung SBRT plan to another whilst they were always higher in 6MV FF Liver plans. BOT was significantly shorter for 6MV FFF plans (the ratio of delivery time for 6FF to 6FFF ranged between 2.24 to 3.72).

Conclusion:

6MV FF SBRT plans were dosimetrically more or less like 6 MV FFF plans. Beams delivery time was significantly shorter for 6MV FFF plans. Further investigation is needed into the correlation between PTV volume/shape and beam delivery time.

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INTRODUCTION

- In our department, we consistently use 6 MVFFF beams along with VMAT to develop SBRT plans in Eclipse 16.1 TPS.
- The dose rate for 6MV FFF is 1400 Mu/min while the highest available for 6MV FF is 600 MU/min, this offers faster beam delivery to the plans and adds more comfort to the patients, in addition to reduced head scattering and leakage radiation and improved dose calculations.
- In this study, we investigated the impact of beam selection FFF vs FF on the dosimetric quality of the treatment plans, actual beam on time and monitor units.

METHODS AND MATERIALS

- Twenty clinical treatment plans (10 lung SBRT and 10 liver SBRT) were developed using 6FFF beams in the Eclipse 16.1 treatment planning system and used to treat patients.
- The average PTV volumes were (27 ± 21 cc) and (82 ± 74 cc) for the lung and liver SBRT plans, respectively.
- These 20 clinical treatment plans were retrospectively replanned using 6FF beams using the same optimization priorities and beam angulations as in the original plans; the 6 FF plans were normalized to maintain the same target coverage as in the 6FFF plans.
- The forty treatment plans (20 clinical 6FFF and 20 replanned 6FF plans) were delivered in dry runs using an Elekta versa HD linear accelerator and the actual beam on time and dose rates for all plans were recorded.
- The 6FFF & 6FF plans were compared in terms of dosimetric parameters (conformity index (CI), Homogeneity index (HI), hot spot (Dmax) and doses to organs at risk (OAR) (for lung treatment plans: lung mean dose and lung V20 %, maximum dose to: esophagus, heart, spinal cord and chest wall D50CC and for liver plans: liver-ITV mean dose and V0cGy, Rt kidney mean dose, maximum dose to skin, spinal cord and body-PTV).
- Monitor units and actual dose rates (upon delivery) of the corresponding plans were also compared.

RESULTS

Table 1 & 2 list the dosimetric parameters, beam delivery time and monitor units for 6FFF and 6FF lung and Liver SBRT treatment plans, respectively. The two tables list average value and standard deviation for each parameter.

Table 1. Dosimetric parameters, beam delivery time and monitor units for Lung SBRT treatment plans.

Volume/OAR	Parameter	6FFF	6FF
PTV	Volume	(27 ± 21) cc	
	Dmax	(73 ± 3) Gy	(74 ± 2) Gy
	D2%	(71 ± 3) Gy	(72 ± 2) Gy
	D98%	(54 ± 0.4) Gy	(54 ± 0.4) Gy
	CI	1.03 ± 0.05	1.03 ± 0.04
	HI	0.27 ± 0.05	0.28 ± 0.03
	Monitor units	3747 ± 588	3865 ± 828
	Beam on Time	(2.5 ± 0.4) minutes	(6.8 ± 1.5) minutes
Lung - ITV	Mean dose	(4 ± 2) Gy	(4 ± 2) Gy
	V20%	(3 ± 2) Gy	(4 ± 3) Gy
Esophagus	Maximum dose	(8 ± 8) Gy	(8 ± 8) Gy
Spinal cord	Maximum dose	(10 ± 4) Gy	(10 ± 4) Gy
Chest wall	D50 cc	(9 ± 3) Gy	(9 ± 3) Gy

Table 2. Dosimetric parameters, beam delivery time and monitor units for Liver SBRT treatment plans.

Volume/OAR	Parameter	6FFF	6FF
PTV	Volume	(82 ± 47) cc	
	Dmax	(56 ± 5) Gy	(57 ± 6) Gy
	D2%	(53 ± 5) Gy	(54 ± 5) Gy
	D98%	(39 ± 5) Gy	(39 ± 4) Gy
	CI	(0.99 ± 0.03)	(0.99 ± 0.02)
	HI	(0.32 ± 0.14)	(0.32 ± 13)
	Monitor units	3066 ± 850	3223 ± 836
	Beam on Time	(2.2 ± 0.6) minutes	(5.7 ± 1.5) minutes
Liver - ITV	Mean dose	(8 ± 5) Gy	(8 ± 5) Gy
	V 0Gy	(1012 ± 103) cc	(1012 ± 103) cc
Body - PTV	Maximum dose	(45 ± 4) Gy	(45 ± 4) Gy
Skin	D 0.5 cc	(16 ± 6) Gy	(16 ± 5) Gy
Spinal Cord	Maximum dose	(7 ± 4) Gy	(7 ± 5) Gy
Rt Kidney	Mean dose	(2 ± 2) Gy	(2 ± 2) Gy

DISCUSSION

- The dosimetric parameters for both 6FFF and 6FF treatment plans are comparable for all lung and liver SBRT plans.
- Monitor unis differences vary from one plan to another in lung SBRT plans and they were always higher in 6FF liver SBRT plans as compared with 6FFF liver SBRT.
- The significant differences were in beam on time: the ratios of beam on time for 6FF plans to 6FFF plans were on the average 2.7 for Lung SBRT plans and 2.6 for liver SBRT plans.
- Nominal Mu/minutes used for treatment planning were 600 and 1400 for 6 FF and 6FFF plans respectively.
- Actual (upon delivery) MU/minute ranged between 1362 to 1452 for 6FFF lung SBRT plans and between 1323 to 1371 for 6 FFF Liver SBRT plans, whilst actual MU/minutes were on the average of 555 and 542 for 6FF lung and liver SBRT plans respectively.

CONCLUSIONS

- No significant differences in dosimetric parameters of 6FFF and 6FF lung and liver SBRT treatments plan were observed.
- Monitor units were always higher in 6FF liver SBRT plans as compared with 6FFF liver SBRT plans. Significant differences were observed in beam on time between 6FF and 6FFF treatment plans.
- The differences in beam on time (between 6FFF and 6FF plans) were more for lung SBRT plans with small and elongated (shape) PTV and PTV that combines 2 lesions.
- Further investigation is needed into the correlation between PTV volume/shape and beam delivery time.

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