Dual Gated Volumetric Modulated Arc Therapy

1. Introduction:
Gated Volumetric Modulated Arc Therapy (VMAT), in conjunction with Flattening Filter Free (FFF) beam delivery, is an emerging treatment modality for Stereotactic Ablative Radiotherapy (SABR) and Stereotactic Body Radiotherapy (SBRT). However, gated delivery significantly prolongs the treatment time since the delivery is only activated during a fraction of the time, typically in a narrow window about the exhale phase. The total Beam On Time (BOT) can be as much as 5.5 times greater depending on the gating window width (1-2). The prolonged treatment time can generate some serious radiobiological concerns(2). Here, in order to enhance the efficiency of gated VMAT delivery, a novel dual gated VMAT, in which dynamic arc deliveries are executed sequentially in alternating exhale and inhale phases, is proposed and evaluated experimentally.

2. Methods:

Treatment Planning: The essence of dual gated VMAT is to take advantage of the natural pauses that occur at inspiration and exhalation by alternatively delivering the dose at the two phases, instead of the exhale window only. The arc deliveries at the two phases are realized by rotating gantry forward at the exhale window and backward at the inhale in an alternative fashion. The gantry rolls back to the position during the beam-off period right after the inhale delivery. Custom XML scripts were developed in Varian’s TrueBeam STx Developer Mode to enable dual gated VMAT delivery. A lung case with 4D CT simulation was selected to demonstrate the novel delivery scheme. RapidArc plans were generated for both inhale and exhale phases. The two plans were then combined into a dual gated arc by interleaving the arc treatment nodes of the two RapidArc plans. Ideal delivery chart is shown in Figure 1.

Measurement setup: As shown in Fig 2 & 3. The dual gated plan was delivered in the development mode of TrueBeam LINAC onto a motion phantom and the delivery was measured by using pinpoint chamber/film/diode array (delta 4). The measured dose distribution was compared with that computed using Eclipse AAA algorithm. The treatment delivery time was recorded and compared with the corresponding single gated plans.

3. Results:
Successful delivery of dual gated treatment has been demonstrated. The pinpoint chamber absolute dose measurement was 0.7% off the calculated dose. On average, 97.5% of the measurement points of double gated VMAT treatment delivery passed the 3% and 3mm γ-test at diode chamber array measurement. The dosimetric result of dose fluence map between measurement and calculation is shown in Fig 4. Relative to a conventional single phase gated plan, treatment time efficiency was improved by 95.5%.

Innovation/Impact: For the first time, a double gated VMAT treatment has been successfully implemented on Varian TrueBeam STx. Treatment time efficiency can be potentially improved with this novel technique by up to a factor of 2. The results show promising application for a variety of tumor sites and delivery modalities.

References:
1. Fox T, Simon EL, Elder E, et al. Free breathing gated delivery (FBGD) of lung radiation therapy: analysis of factors affecting clinical patient throughput. Lung Cancer 2007;56:69-75.
2. Murphy MJ, Lin PS, Ozhasoglu C. Intra-fraction dose delivery timing during stereotactic radiotherapy can influence the radiobiological effect. Med Phys 2007;34:481-484.