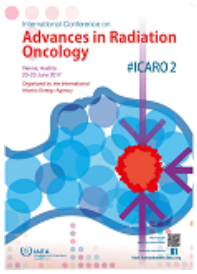

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Peripheral dose of moving target simulation using In-House dynamic thorax phantom

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Peripheral Dose of Moving Target Simulation using In-House Dynamic Thorax Phantom
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Purpose
The aims of this study were to explain the interplay effect at peripheral dose characteristics of target and organ at risk for target movement.

Materials and Method
This work was performed at MRCCC Siloam Hospital using Varian RapidArc Linear Accelerator with 6 MV photon energy. The dynamic in-house thorax phantom was employed to simulate the radiotherapy of lung with organ at risk present. It was designed with movable tumor target in the phantom in right lobe. The dose simulation was generated using Varian Eclipse 11.0 with Progressive Resolution Optimizer (PRO) and Anisotropic Analytical Algorithm (AAA) algorithm methods for optimization and dose calculation, respectively. The total dose was simulated using 60 Gy for 30 fractionations or 200 cGy per fraction. For IMRT planning, 7 fields were planned with 2 MLC angles of 0o and 90o, whereas the VMAT plan used double partial arc technique. Experiments were carried out to measure the target dose in static and dynamic target movement simulation. For the dynamic mode, the target was in harmonic motion with amplitudes of 5, 10, and 20 mm for periode of 1, 1.5, and 2 seconds, respectively. For measurements, TLD 100 LiF:Mg,Ti rod and GafChromic EBT3 film were employed. The GafChromic EBT-3 film was cut and equal with size of target of the tumor to cover all of target areas, whereas the TLDs were inserted into 5 points of target at the center, peripheral areas and also at OAR area.

Result and Discussion
A calibration curve was generated by plotting optical density at the center irradiated calibration film and prescribed dose. The output of linac machine indicated the accuracy with discrepancy less than 2%, being still in tolerance range. For optimizing the planning of IMRT and VMAT at MLC 0o, we found that the dose of Planning Target Volume (PTV) in the range of 194,5 to 208,0 cGy and average dose of 203,6 cGy for IMRT techniques, whereas the PTV dose in the range of 194,9 to 208,7 cGy and dose average of 201,9 cGy for VMAT techniques. On the other hand, the OAR dose were in the range of 0,49 to 49,9 cGy and between 0,4 cGy to 54,7 cGy for IMRT and VMAT, respectively. Futhermore, for optimization of MLC 90o, the PTV dose between 161,4 cGy and 210,2 cGy dan OAR dose between 0,3 cGy and 51,0 cGy for IMRT technique, whereas it was in the range of 174,3 cGy to 207,9 cGy and between 0,3 cGy to 49,9 cGy for VMAT technique.
For the comparison of dose measurement between MLC 0o and 90o for IMRT technique, we found that the PTV dose at the center tend to be lower than the peripheral dose. Subsequently, the PTV and OAR dose at MLC 0o is lower than to PTV and OAR dose at MLC 90o. In line with IMRT technique result, it also tend to give similar pattern for VMAT technique at MLC0o and 90o.
For target of dynamic motion in superior–inferior direction, we explored that the dose was increased linearly with amplitude of the motion. In all measurements, the dose with an amplitude of 20 mm was the greatest values in both film and TLD detectors. Discrepancy of PTV dose at inferior position between the planned and the measured dose at MLC with 90o tend to be higher in comparison to the other areas, meaning that the MLC tend to interact with the inferior part of the target during exhalation process and dose in this area was attenuated by MLC, thus becoming underdose. On the other hand, the discrepancy between planned and measurement dose of MLC 0o presented a small deviation for superior and inferior region in same direction

of respiratory motion. This result explained that interplay effect would be easy to see when the leaf is moving perpendicular with the tumor movement direction. Then, the interplay effect at parallel movement can be neglected.
For OAR dose, this study presented a similar indication as the target dose measurement, i.e. the dose was influenced by the rise of amplitude of the traget motion. All of the measured dose at target movement was significantly different to TPS. This difference took place because of the planned dose was calculated the static position of the phantom, while it was being a harmonic oscillation during the measurement.

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