Dosimetric Evaluation Of Treatment Planning Algorithms In Lung Equivalent Heterogeneous Medium For IMRT And VMAT

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INTRODUCTION

- A low-density medium, such as the lung in a small field usually leads to challengingly estimating dose. As a result, the selection of the treatment planning algorithms for the estimation of dose in small fields in low-density medium and a detector verifying the planned dose is important for the intended outcome.

INTRODUCTION…

- The dose estimation accuracy can only be improved if TPS employs high-quality algorithms that include multisource modelling to monitor each secondary scattered photon and electron and its subsequent dose deposition in non-equilibrium conditions.

AIM AND OBJECTIVE

The study has been undertaken to evaluate

- Assessing Dosimetric Variations in Lung Equivalent Heterogeneous Medium for Intensity-Modulated Radiation Therapy (IMRT) and Volumetric Modulated Arc Therapy (VMAT) with Treatment Planning Algorithms.
- The position verification distribution characteristics in lung radiotherapy, in order to provide the reference for the clinical radiotherapy technology optimization of lung equivalent heterogeneous medium.

MATERIALS AND METHODS…

- In this experimental study, Computerized Imaging Reference System (CIRS) phantom was used with an inhomogeneous Racemosa wood cylinder for two types of tumors, namely, Left Lung Central Tumor (LCT) and Left Lung Peripheral Tumor (LPT) in the CIRS left lung cavity.
- The CT datasets were employed with the generation of VMAT, d- IMRT and ss-IMRT plans for the LCT and LPT irradiated with 6 MV photon beam. In this study, the accuracy and efficacy of two algorithms: Monte Carlo (MC) and the Pencil Beam (PB), from the Monaco treatment planning system (TPS), were tested by using Gafchromic EBT3 films and CIRS thorax phantom in order to design a VMAT plan and IMRT plan under the guidance of image-guided radiotherapy (IGRT).

Figure: CIRS thorax phantom wood cylinder made of Ficus Recemosa wood slabs with CT and High energy linear accelerator “Infinity” with XVI system

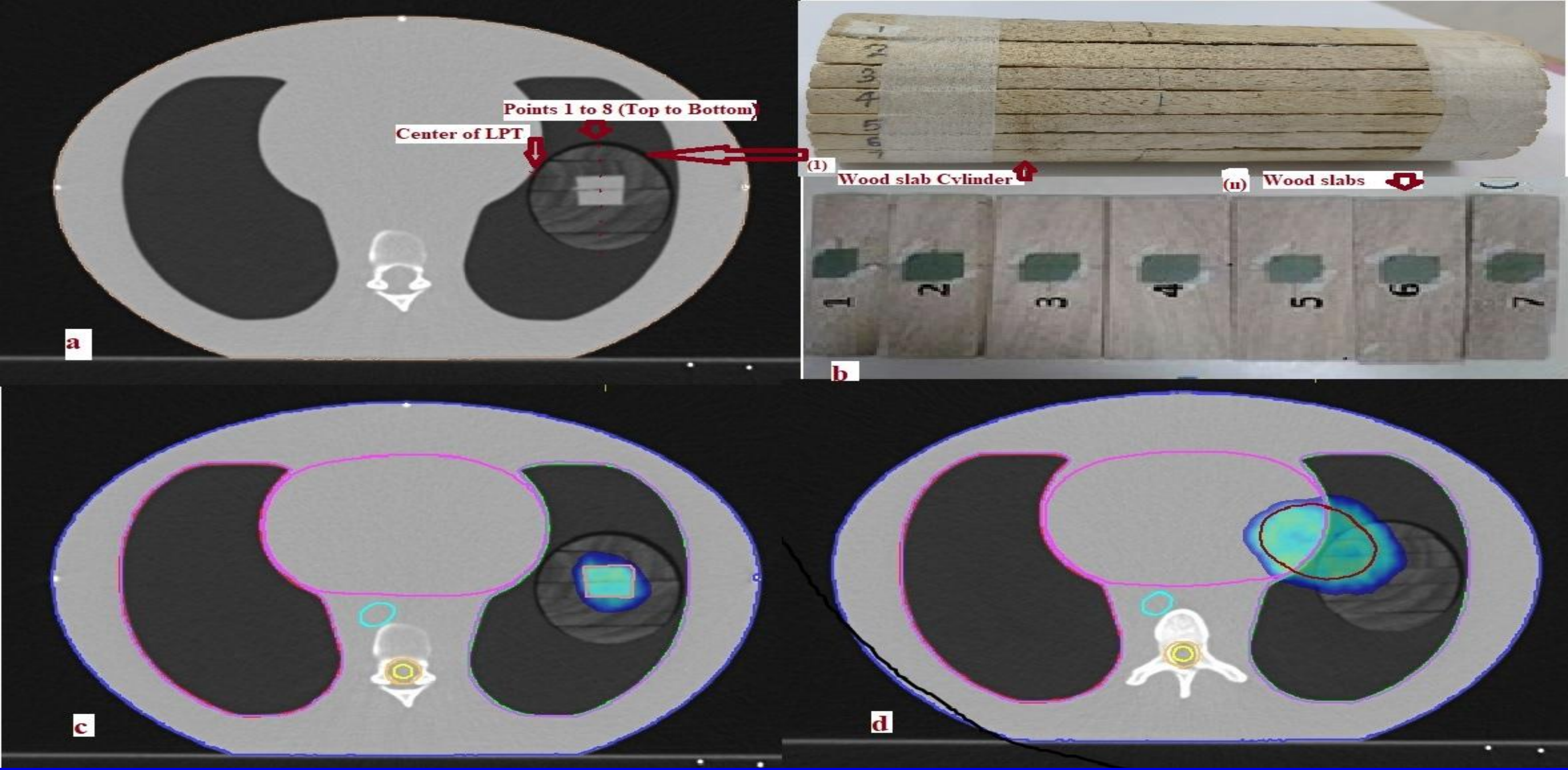


Figure : (a) central axis point 1 to point 8 for Left Lung Central Tumor (LCT) and center of Left Lung Peripheral Tumor (LPT), (b) (I) wood slab cylinder for the cavity of computerized imaging reference systems Thorax phantom, (II) seven wood slabs with Gafchromic film for dose measurements inside the wood cylinder in total of eight surfaces, (c) location of LCT, and (d) location of LPT.

RESULTS

The CBCT with kV-XVI was acquired and matched for the CIRS phantom, aligning it with reference images to replicate and verify the accuracy of orientation.

Correction Direction	Before correction	After correction
X	0.89	0.04
Y	0.02	0.01
Z	0.11	0.03
Pitch, Roll and Yaw	Lees than 0.1^0	

Table : The mean setup error of the correct treatment and after the placement error difference(mm).

RESULTS

Evaluation Points	Dose Difference Calculated vs. Measured in percentage					
	ss-IMRT		d-IMRT		VMAT	
	PBA	MCA	PBA	MCA	PBA	MCA
1	+12.9	-2.1	+12.5	-1.6	+12.5	-1.2
2	+10.8	-1.9	+9.1	-1.4	+10.5	-1.1
3	+10.5	-1.6	+9.8	-1.1	+11.6	-1.0
4	+11.6	-1.4	+10.5	-0.9	+10.2	-0.8
5	+11.8	-1.9	+9.6	-1.4	+11.7	-1.2
6	+11.2	-1.8	+9.5	-1.5	+12.4	-1.1
7	+11.5	-2.2	+10.8	-1.7	+11.8	-1.2
8	+11.9	-2.4	+11.5	-1.9	+11.6	-1.1

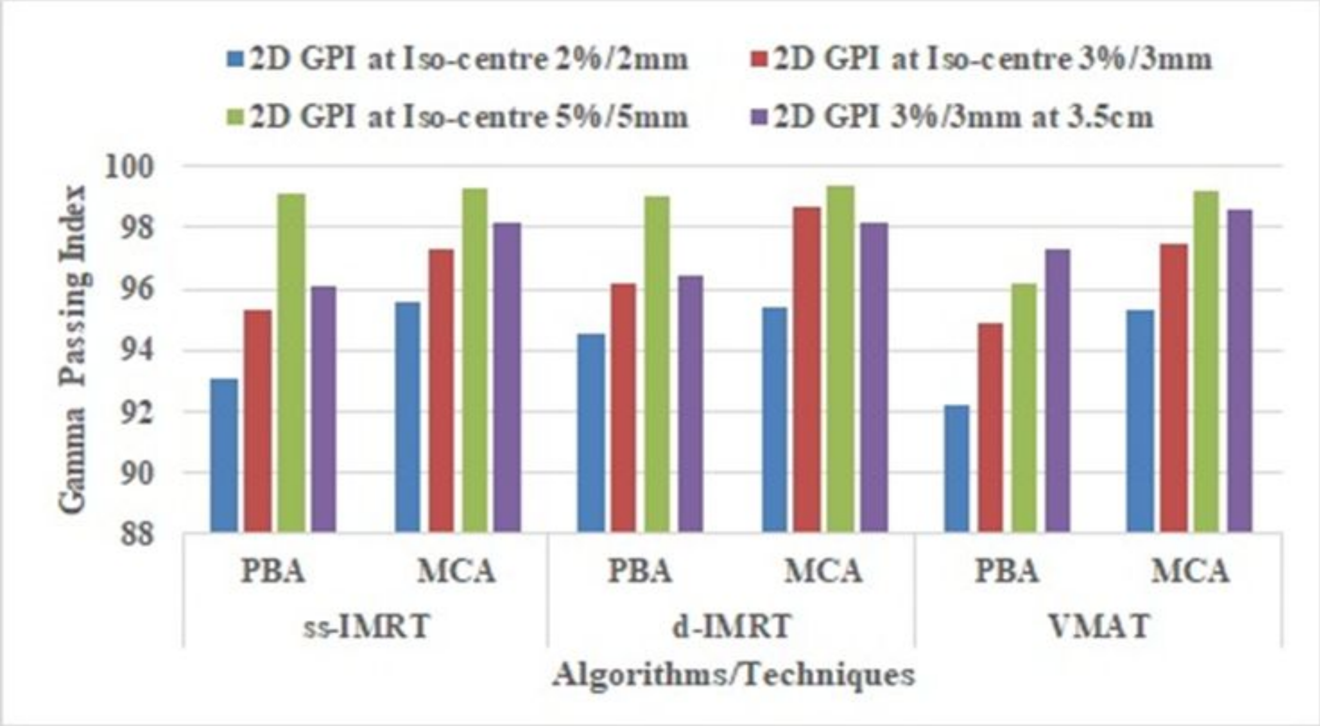
Table : Dose variation utilizing Gafchromic film and several treatment planning system dose calculation algorithms for Left Lung central tumor (LCT)

RESULTS…

Evaluation Points	Dose Difference Calculated vs. Measured in percentage					
	ss-IMRT		d-IMRT		VMAT	
	PBA	MCA	PBA	MCA	PBA	MCA
Peripheral Dose	+13.0	-2.6	+12.5	-2.1	+12.7	-1.5

Table : Dose variation utilizing Gafchromic film and several treatment planning system dose calculation algorithms for left lung peripheral tumor (LPT)

RESULTS…



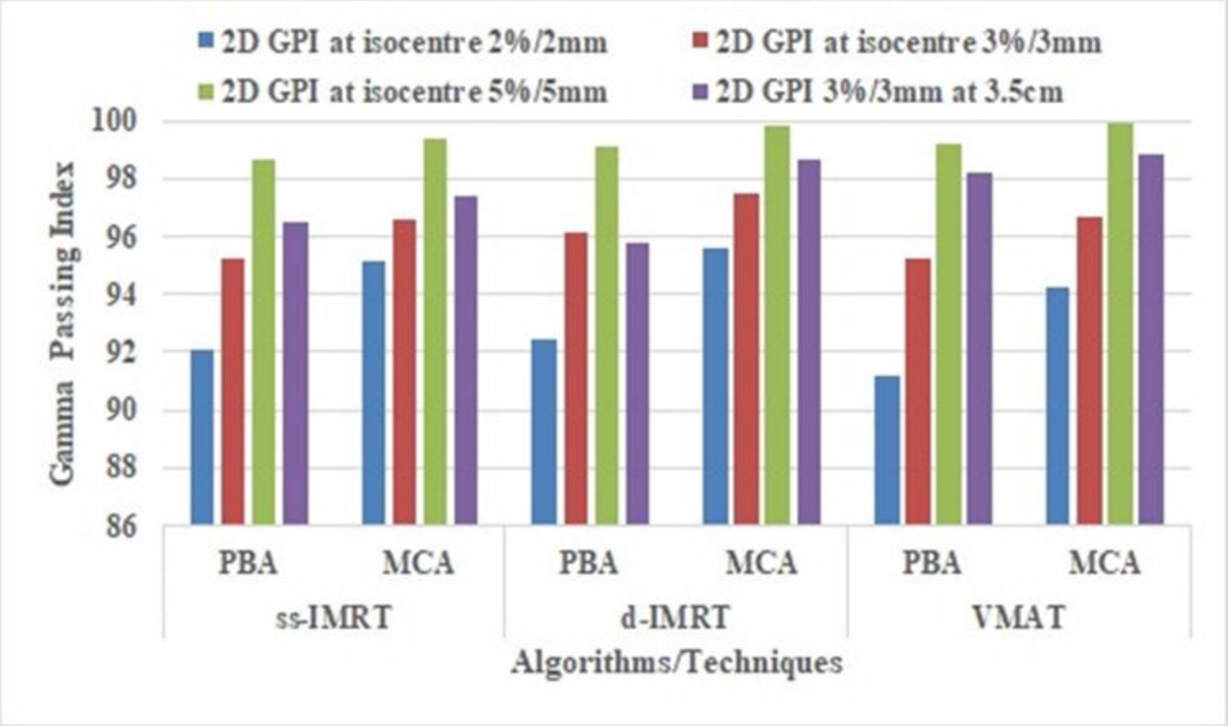


Figure . Algorithms/techniques gamma passing index variation between Gafchromic film fluence and treatment planning system dose fluence for left lung central tumor (LCT) and left lung peripheral tumor (LPT) with different passing criteria.

DISCUSSION

- Previous evidence contrasted particular algorithms with theoretical Monte Carlo evidence or dose derived for a single tumor in the center of the lung (mostly).
- This study evaluated the reliability of algorithms with measurements taken at the central plane and the interface target of the lung(PB and MC with IMRT & VMAT).
- Alagar AGB et al. presented that maximum deviation among the algorithms was in the inter-face/junction of the lung and tumor.

DISCUSSION

- In the present study, regardless of delivery mode, MC and PB algorithms exhibited the highest variation near the tumor-lung junction in both central and interfaced tumors.
- However, the variation with PBA was greater than MCA-generated VMAT plan, with a minimal permissible deviation of 0.8% , related to the lower accuracy of algorithm in simulating the enhanced transverse scattering phenomenon in low-density mediums.
- This study found that VMAT (MC algorithm) guided by IGRT effectively corrected placement error.

SUMMARY AND CONCLUSIONS…

- The variation in lung equivalent heterogenous phantom for the PB algorithm is noticeably higher (Compared with MC). For both the PB and MC algorithms, the variation is slightly higher in peripheral tumors compared to central lung tumors.
- The MC algorithm, which is used to calculate dose in heterogeneous media, is equally accurate. Thus, patient-specific absolute dosimetry should be performed using a heterogeneous phantom that closely resembles the density and tissue composition in real patient scenario.
- In addition, CBCT improved radiotherapy accuracy and reducing unnecessary in radiotherapy. So CBCT guided VMAT is a potential effective treatment for lung cancer and may be more effective than IMRT.

"The beauty of research is that you never know where it's going to lead."

RICHARD ROBERTS
Nobel Prize in Physiology or Medicine 1993