Effect of gastrointestinal gas in dose calculation for lung cancer patients

A. I. Saito[1,2], J. G. Li[2], C. Liu[2], K. R. Olivier[2], J. F. Dempsey[1,2]

1. ViewRay Inc., Gainesville, FL, http://www.viewray.com

2. Department of Radiation Oncology, University of Florida, Gainesville, FL

INTRODUCTION

Heterogeneity correction is required for accurate dose calculations in radiotherapy to compensate for the differences resulting from the variability of different density tissues. Normally, with CT imaging these correction are made using Housfield units (HU) to electron density conversion tables. However, if another modality such as MRI is used for treatment planning, HUs cannot be used to determine the density in the patient. Another method of performing heterogeneity corrections without using HU must be investigated.

PATIENTS AND METHOD

Conformal lung-carcinoma treatment plans for both standard fractionation and hypofractionation with 4 levels of bulk electron densities were generated for 32 lung cancer patients with 35 tumors sites using a commercial treatment planning system with an adaptive convolution algorithm for tissue heterogeneity correction (Pinnacle3, Philips Medicals Systems, Shelton, Connecticut, USA). CT scans taken from patients with their CT scans taken with a contras medium were not used in this study.

For each case, two plans were generated. The first was a bulk density plan with the population averaged densities of 0.15, 0.29, 0.99, and 1.12 g/cc densities assigned to air, lung, soft tissue, and bone, respectively, for the entire set of patients as used in our previous study; the areas were identified by an isodensity segmentation tool. The second plan was a bulk density plan using the same parameters except for the gastrointestinal gas where we applied the soft tissue density of 0.99 g/cc instead of the air density of 0.15 g/cc. Monitor units were kept constant and no normalizations were employed. Dose volume histograms (DVH) and dose difference distributions for the two plans were compared for all cases.

PURPOSE

Previously, we have reported that heterogeneity dose calculation employing only 4 levels of electron densities corresponding to air, lung, soft tissue, and bone provides an accurate method of dose calculation with the exception of patients exhibiting bullous emphysema. However, besides the trachea, the air region also includes gastrointestinal gas which could enlarge, shrink, or disappear during fractionated treatment depending on the patient's condition. The aim of this study was to investigate the influence of gastrointestinal gas on dose calculation accuracy of lung cancer patients when using a 4 tissue bulk density correction method.

RESULTS

Of the all lung tumors in the study, 10 tumors were located in the right upper lobe, 6 in right middle lobe, 5 in right lower lobe, 7 in left upper lobe and 7 in left lower lobe. The median planning target volume (PTV) of the 35 tumors was 119.7 cm³ (range, 4.2 – 1001.1 cm³). The median volume of the entire gastrointestinal gas volume and of the volume overlapping the PTV in the superior-inferior directions were 21.7 cm³ and 0.3 cm³, respectively. The median numbers of beam for each tumor were 4 (range 2-7).

In all cases, the DVH for the target volume where matched to far better than 1% in both volume and dose. In the worst case, the DVH for the target volume showed ~1% difference. In all patients the 2 DVHs for all the normal tissue matched perfectly. When comparing the dose distribution slice by slice, in all cases all slices showed an agreement with difference less than 4%, with the differences isolated to very small volumes. There was no difference greater than 1% in the dose to the target volume, even in the 8 patients for whom the relative volume of gastrointestinal gas to the tumor at the same slices was larger than 1% (1%, 1.3%, 1.9%, 2.2%, 4.4%, 8%, 8.3% and 11.8%).

Figure 1a. DVH of a case with good agreement.

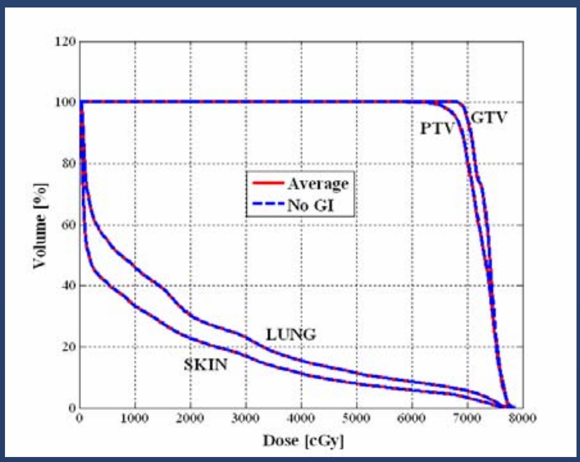
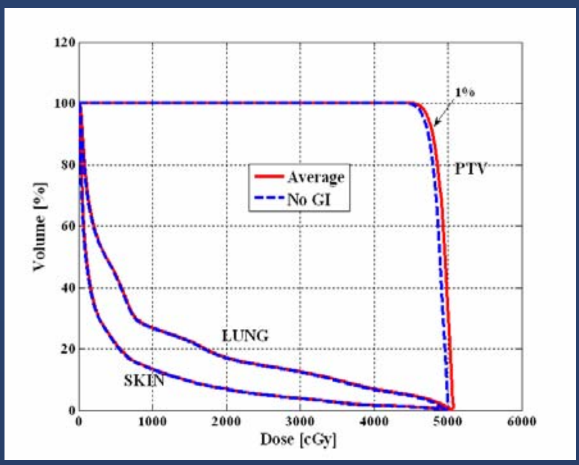


Figure 1b. DVH of a case with the worst agreement.



Average: DVH of the bulk density plan with the population averaged densities with the gastrointestinal gas assigned as air.
No GI : DVH of the bulk density plan with the population averaged densities with the gastrointestinal gas assigned as soft tissue.

Figure 2a. Slice by slice comparison at the height inferior to the PTV (the case with a spot of the highest discrepancy).

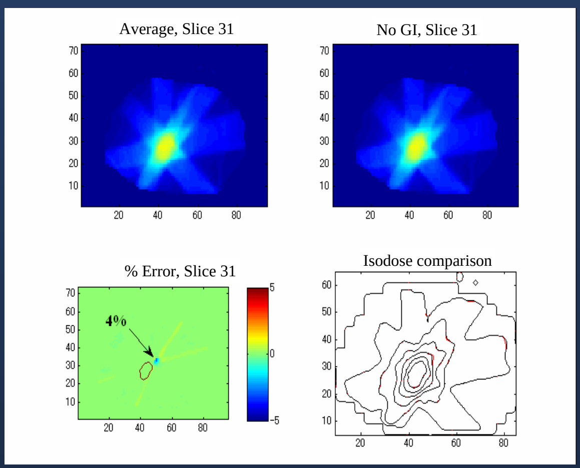
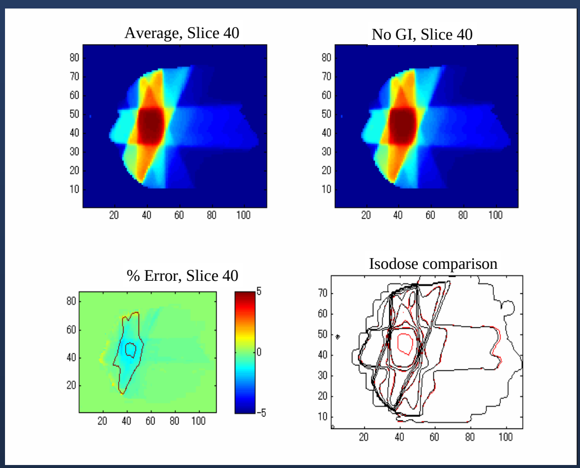


Figure 2b. Slice by slice comparison at the height of the target (the case with the worst agreement observed on the DVH.)



Average : bulk density plan with the population averaged densities with the gastrointestinal gas assigned as air.
No GI : bulk density plan with the population averaged densities with the gastrointestinal gas assigned as soft tissue.
% Error : % difference between the 2 plans.
Isodose comparison: comparison of the isodose line between the 2 plans.

CONCLUSIONS

Gastrointestinal gas showed little influence on normal tissue and target dose calculation in all examined patients for whom the relative gastrointestinal gas volume to the target at the same slices as the tumor was up to 11.9%. Therefore, while gastrointestinal gas size may change depending on the patient's condition, no special correction would be needed. And if non-CT modality imaging such as MRI would be used for treatment planning in lung cancer patients, there would be no need to assign the gastrointestinal gas as air density for the heterogeneity correction .