Influence of respiratory motion on target dose verification in IMRT for lung cancer radiotherapy

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INTRODUCTION

Intensity modulated radiation therapy (IMRT) has become one of the main approaches of conventional radiotherapy for lung cancer. In order to minimize the dose of the surrounding normal tissues without compromising the target coverage in the treatment, in addition to precise positioning, precise planning and precise delivery, it is also essential to carry out high quality assurance (QA) and quality control (QC).

The treatment plans used in IMRT radiotherapy for lung cancer are usually evaluated according to the dose distributions. Most of the studies are based on the static mode . In fact, except for the patient who is holding breath under the mode of active gating technique, other patients are receiving radiotherapy during the free breathing. Therefore, none of the above studies of dose verification based on static state have assessed the impact of respiratory motion and cannot accurately reflect the actual irradiation dose received by patients.

AIM

To study the effect of respiratory movement on IMRT dose verification of lung cancer based on the real respiratory movement parameters of patients.

METHOD

Fifty-eight patients lung cancer were enrolled in this study. contoured gross tumor volumes on ten phases of 4DCT images, setting the GTV of 50% respiratory phase as the benchmark, the motion amplitude of tumor in X (left and right), Y (anterior and posterior) and Z (superior and inferior) directions was calculated according to the boundary coordinates of GTVs in 10 phases.

The respiratory frequency collected during the 4DCT scanning is converted into respiratory cycle, and the motion amplitude is obtained from the range of tumor movements. The respiratory device was a 008pl dynamic platform (CIRS, Norfolk, VA, USA).

Each treatment plan was transmitted to the QA module, and angles of all fields were set as 0 degree to generate a QA plan. The plan verification was measured in the Edge accelerator.

Input the parameters of respiratory frequency and respiratory amplitude into the software, and simulate the real respiratory state of patients on the platform. Compare the gamma pass rate of breathing state and static state.

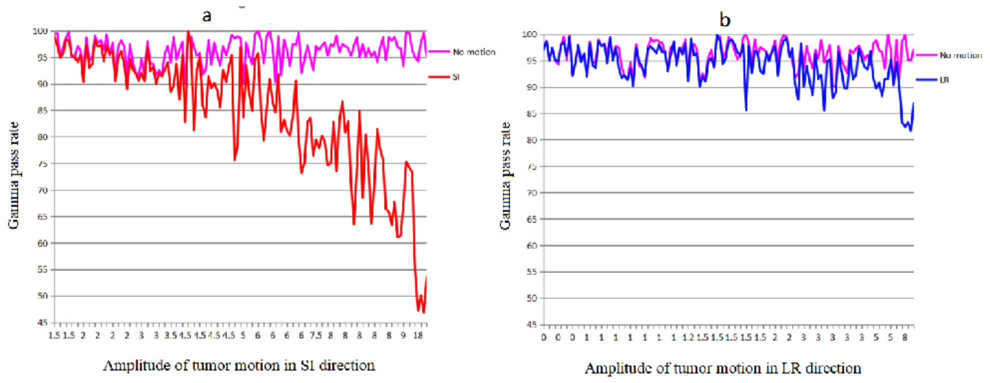
The collected dose distribution and planned dose distribution were analyzed with the gamma analysis with passing criteria of 3%/3 mm and 10%, and the rate > 90% was set as pass.

RESULTS

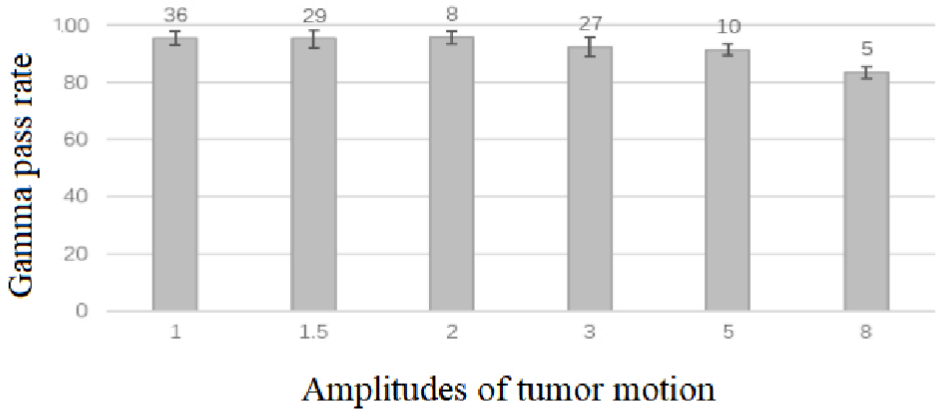
The average value of the gamma pass rate in the breathing state is lower than that in the static state (p <0.001), and the gamma pass rate gradually decreases as the amplitudes of tumor motion increases.

Amplitude (mm)	Number of the fields with gamma < 90%	Gamma pass rate		P value
		static	respiratory	
≤2	30	96.2±2.5	94.9±2.5	<0.001
≤3	36	95.8±2.6	94.5±2.7	<0.001
≤4	41	95.6±2.6	94.1±2.7	<0.001
≤5	69	95.8±2.6	92.2±4.9	<0.001
≤6	89	95.9±2.7	90.5±6.0	<0.001
≤8	116	96.1±2.5	87.1±8.7	<0.001
≤9	125	96.2±2.5	85.6±10.1	<0.001
≤18	129	96.2±2.5	84.5±11.7	<0.001

The average respiratory frequency of the patients was 3.3 seconds. The average amplitude of tumor motion (5.6 mm) in the SI direction was greater than the LR direction (2.1 mm) and the anterior-posterior (AP) direction (2.3 mm), with the maximum amplitude as 18 mm. The average gamma pass rate in the breathing state in the SI and LR directions is lower than the static state (p <0.001), and both increase gradually with the increase of tumor motion. When the amplitude of tumor motion is greater than 3mm, the gamma pass rate of the shooting field starts to be less than 90%. When the tumor motion amplitude is greater than 7 mm in the SI direction, the gamma pass rates of all shooting fields are less than 90%. There is no statistical difference in the gamma pass rate between different respiratory cycles.



The gamma pass rate of all shooting fields of the SI and LR directions in the static state and the breathing state. a. The shooting field is arranged according to the order of the amplitude in the SI direction. b. The shooting field is arranged in the order of the amplitude in the LR directions.



The gamma pass rate of LR direction with different amplitudes of tumor motion in respiratory state

CONCLUSIONS

The IMRT dose verifications based on the real respiratory movement parameters of patient show that amplitude is an important factor of dose verification, while the respiratory cycle has no effect on dose verification. When the amplitude is more than 3 mm, the gamma pass rate starts to be less than 90%. It is suggested to take corresponding measures to control the tumor motion amplitude.

ACKNOWLEDGEMENTS

Not applicable

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CONTACT INFORMATION

Investigate the influence of respiratory motion on dose verification in IMRT for patients with lung cancer based on 4DCT images