Medical Dosimetry 37 (2012) 47-52

Medical Dosimetry

journal homepage: www.meddos.org

Comparison of setup error using different reference images: a phantom and lung cancer patients study

Bo Jiang, Ph.D., Jianrong Dai, Ph.D., Ye Zhang, M.D., Ke Zhang, M.S., Kuo Men, M.S., Zongmei Zhou, M.D., Jun Liang, M.D., and Lvhua Wang, M.D.

Department of Radiation Oncology, Cancer Institute (Hospital), Chinese Academy of Medical Sciences, Peking Union Medical College, Beijing, China

ARTICLE INFO

Article history:
Received 5 July 2010
Accepted 9 January 2011

Keywords:
Cone-beam CT
Setup error
4DCT
Average CT image

ABSTRACT

The purpose of this study was to compare setup errors obtained with kilovoltage cone-beam computed tomography (CBCT) and 2 different kinds of reference images, free-breathing 3D localization CT images (FB-CT) and the average images of 4-D localization CT images (AVG-CT) for phantom and lung cancer patients. This study also explored the correlation between the difference of translational setup errors and the gross tumor volume (GTV) motion. A respiratory phantom and 14 patients were enrolled in this study. For phantom and each patient, 3D helical CT and 4D CT images were acquired, and AVG-CT images were generated from the 4D CT. The setup errors were determined based on the image registration between the CBCT and the 2 different reference images, respectively. The data for both translational and rotational setup errors were analyzed and compared. The GTV centroid movement as well as its correlation with the translational setup error differences was also evaluated. In the phantom study, the AVG-CT method was more accurate than the FB-CT method. For patients, the translational setup errors based on FB-CT were significantly larger than those from AVG-CT in the left-right (LR), superior-inferior (SI), and anterior-posterior (AP) directions ($p < 0.05$). Translational setup errors differed by >1 mm in 32.6% and >2 mm in 12.9% of CBCT scans. The rotational setup errors from FB-CT were significantly different from those from AVG-CT in the LR and AP directions ($p < 0.05$). The correlation coefficient of the translational setup error differences and the GTV centroid movement in the LR, SI, and AP directions was 0.515 ($p = 0.060$), 0.902 ($p < 0.001$), and 0.510 ($p = 0.062$), respectively. For lung cancer patients, respiration may affect the on-line target position location. AVG-CT provides different reference information than FB-CT. The difference in SI direction caused by the 2 methods increases with the GTV movement. Therefore, AVG-CT should be the prefered choice of reference images.

© 2012 American Association of Medical Dosimetrists.

Introduction

High geometrical accuracy is an important precondition for clinical application of intensity-modulated radiation therapy (IMRT). Several factors affect the geometrical accuracy, which includes delineation uncertainties of the gross tumor volume (GTV) and the clinical target volume, organ positional variations within patients, and patient setup variations.[1] Image-guidance devices have been implemented in clinic to address this issue.[2,3] Because of high image quality and compactness, on-board kilovoltage cone beam computed tomography (CBCT) has been used more frequently. Borst *et al.*[4] evaluated clinical CBCT setup errors for lung cancer patients and observed systematic setup errors of 3.1, 4.0, and 2.0 mm in the left-right (LR), superior-inferior (SI), and anterior-posterior (AP) directions, respectively, if no corrections were performed. Other authors presented similar data on setup errors.[5,6]

Many radiotherapy centers use free-breathing 3D localization CT images (FB-CT) as the reference images for registering in the image guidance procedure. As 4D CT (4DCT) is more widely used in radiotherapy process, the average-CT (AVG-CT) derived from the 4DCT was used to detect setup errors as reference images. However, there are few studies of clinical data concerning the setup of lung cancer patients using the AVG-CT for localization. The applicability of AVG-CT for localization for on-line image guidance has not compared with the conventional FB-CT image approach. It is not clear which method is more accurate for localization.

In this study, we consider 2 reference images for measuring setup errors of phantom and lung cancer patients. The first method is the

Reprint requests to: Jianrong Dai, Ph.D., Department of Radiation Oncology, Cancer Institute (Hospital), Chinese Academy of Medical Sciences, Peking Union Medical College, Panjiayuan Nanli 17, Chaoyang District, Beijing 100021, China.

E-mail: jiangbo122@126.com

0958-3947/$ – see front matter Copyright © 2012 American Association of Medical Dosimetrists
doi:10.1016/j.meddos.2011.01.001

Table 1
Patient characteristics and magnitude of GTV centroid motion

						Motion of GTV centroids		
Patient No.	Sex	Age (y)	Stage	Tumor Location	Volume of IGTV (cm^3)	Range of RL (mm)	Range of SI (mm)	Range of AP (mm)
1	M	48	T2N1M0	RUL	63.5	2.0	3.4	1.0
2	M	56	T3N0M0	RLL	134.2	3.0	9.0	1.7
3	M	52	T2N0M0	RUL	85.4	1.0	4.7	2.1
4	M	46	T2N1M0	RLL	79.4	1.8	13.9	1.0
5	M	63	T1N1M0	LLL	53.3	4.2	6.4	6.0
6	M	72	T2N1M0	RUL	127.8	0.7	2.1	0.7
7	M	65	T3N0M0	RUL	105.4	4.3	4.4	0.4
8	M	58	T3N0M0	LLL	94.6	3.7	13.4	4.7
9	F	58	T2N1M0	RUL	77.4	0.7	3.6	2.9
10	M	64	T1N0M0	RLL	82.3	3.1	4.6	1.5
11	M	67	T3N1M0	RUL	140.3	0.5	2.8	0.5
12	M	55	T2N1M0	RLL	90.7	3.8	7.5	4.9
13	M	52	T3N0M0	RLL	103.4	3.0	9.1	4.1
14	M	60	T3N1M0	RLL	92.6	4.0	8.4	3.5
Mean	—	—	—	—	95.0	2.6	6.7	2.5
SD	—	—	—	—	25.4	1.4	3.7	1.9

RUL, right upper lobe; RLL, right lower lobe; LLL, left lower lobe; IGTV, internal gross tumor volume.

conventional procedure in which FB-CT images are used as reference images when registering daily CBCT images. The second method is to replace FB-CT images with AVG-CT images as reference images. The aim of this paper is to compare the setup errors measured with the FB-CT and AVG-CT images and attempt to find a superior registration method for lung cancer patients. In addition, we measured the GTV centroid movement and evaluated the correlation between the translational setup error differences (between the FB-CT image and AVG-CT image registration) and the GTV centroid movement.

Methods and Materials

Acquisition of simulation CT images

Fourteen lung cancer patients who received image-guided IMRT were enrolled in this study. Patient and tumor characteristics are listed in Table 1. For each patient, the treatment simulation was performed on a CT simulator (Brilliance Big Bore; Philips Medical Systems, Andover, MA) with a slice of 3 mm. The patients were in the supine position and immobilized with individualized thermoplastic sheet (Klarity, Guangzhou, China). First, a session of conventional CT scanning was performed to obtain the FB-CT images for the entire thoracic region. Then, a respiration-correlated 4DCT session was performed to obtain the 4DCT images for the same region.

During the 4DCT session, the patient's respiration was monitored with the Real-Time Position Management system (Varian Medical Systems, Palo Alto, CA). Based on the respiratory signal (r.p.m.), the respiratory cycle was divided into 10 phases. The 4DCT process has been described in detail previously.[7,8] The 4DCT images were used to evaluate the GTV's motion and produce the AVG-CT that was generated by direct-averaging each voxel intensity in all phases of the 4DCT data using the simulator's software.

In this study, all patients were performed using nongating treatment. AVG-CT was used both as planning and reference images. The FB-CT was used only as reference image for image registration.

Acquisition of CBCT images

The free-breathing CBCT images were acquired with a gantry-mounted kV on-board imaging system (Synergy; Elekta Oncology systems, Crawley, UK). The lung cancer patients underwent scanning with an image-guidance protocol acquiring approximately 640 projections in 2 min to complete a full rotation. A medium field of view (41 cm in diameter) was used. The frequency of CBCT acquirement depended on the total number of fractions and the desired level of treatment accuracy for each patient. Total 142 CBCT scans for all 14 patients (range 5–16 scans/patient) were acquired.

Setup measurements based on CBCT

The FB-CT images, AVG-CT images, structure sets, and radiotherapy plan were transferred to the Elekta XVI software from the treatment planning system (Pinnacle, version 7.6c; Philips/ADAC, Milpitas, CA). The planning isocenter was used as a reference point for registration. According to the image guidance protocol, the match procedure included a patient-specific alignment clipbox of interest that included the planning target volume (PTV) and other regions of interest. The isocenter is located at the clipbox's center. Then, the FB-CT images and AVG-CT images were registered to the CBCT, respectively, using the "grey value" automatic alignment algorithm with the commercial Elekta XVI software. The algorithm is designed for matching bony and soft tissues, and uses the correlation ratio voxel similarity metric.[9] After the registration, the translational and rotational setup errors were recorded.

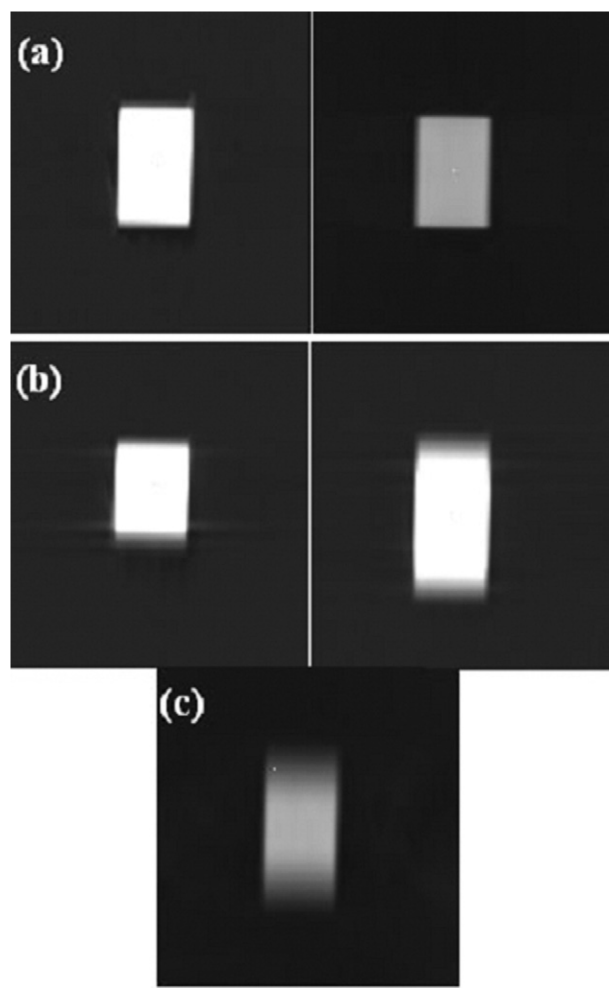

Fig. 1. Coronal sections from the CT images of the phantom. (a) Stationary phantom: the left image is the FB-CT; the right is the FB-CBCT. (b) Phantom moving with 2-cm amplitude: the left image is FB-CT; the right is the AVG-CT. (c) The FB-CBCT image with 2-cm amplitude.

Download English Version:

https://daneshyari.com/en/article/1885119

Download Persian Version:

https://daneshyari.com/article/1885119

Daneshyari.com