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Original research article

Influence of the contrast agents on treatment planning dose calculations of prostate and rectal cancers

Sahel Heydarheydari[a], Negin Farshchian[b], Abbas Haghparast[a,*]

[a] Department of Biomedical Physics and Engineering, Faculty of Medicine, Kermanshah University of Medical Sciences, Kermanshah, Iran

[b] Department of Radiation Oncology, Faculty of Medicine, Kermanshah University of Medical Sciences, Kermanshah, Iran

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ABSTRACT

Aim: The aim of the present study is to quantify differences in dose calculations caused by using CA and determine if the resulting differences are clinically significant.

Background: The influence of contrast agents (CA) on radiation dose calculations must be taken into account in treatment planning.

Materials and methods: Eleven patients with pelvic cancers were included in this study and two sets of CTs were taken for each patient (without and with CA) in the same position and coordinates. Both sets of images were transferred to the DosiSoft ISOgray treatment planning system for contouring and calculating the dose distribution and monitor units (MUs) with Collapsed Cone and Superposition algorithms, respectively. All plans were generated on pre-contrast CT and subsequently copied to the post-contrast CT. Radiation dose calculations from the two sets of CTs were compared using a paired sample *t*-test.

Results: The results showed a statistically insignificant difference between pre- and post-contrast CT treatment plans for target volume and OARs ($p > 0.05$), except bladder organ in the prostate region ($p < 0.05$) but the relative mean dose and MU differences were less than 2% in any patient for 18 MV photon beam.

Conclusions: Treatment planning on contrasted images generally showed a lower radiation dose to both target volume and OARs than plans on non-contrasted images. The results of this research showed that the small radiation dose differences between the plans for the CT scans with and without CA seem to be clinically insignificant; therefore, contrast-enhanced CT can be used for both target delineation and treatment planning of prostate and rectal cancers.

1. Background

Cancer as a major neoplastic disease is an important global public health concern worldwide.[1] During the past decade, the incidence of pelvic cancers such as colorectal, prostate,

* *Corresponding author*. Tel.: +98 9183334998; fax: +98 8334276477.
E-mail address: a.haghparast@kums.ac.ir (A. Haghparast).

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and cervical cancers were increasing in many countries of the Asia-Pacific region such as China, South Korea, and Iran.[2,3] Nowadays, pelvic irradiation is an essential part of the curative treatment strategy of pelvic malignancies, including rectal, prostate, and cervical carcinoma.[4] One of the major limiting factors for radiotherapy is the lack of contrast in the absorption of ionizing radiation between healthy and cancerous tissues. Most current efforts to defeat this problem focus on methods which spatially conform the dose to the tumor volume through improvements in treatment planning facilities and imaging.[5] However, this situation can be further improved through the introduction of contrast agents (CAs) where they have been used extensively in conjunction with imaging techniques such as computed tomography (CT).[6] CA is commonly used in CT simulation to assist radiation oncologists in defining regions of interest (ROI), so that normal and malignant tissues can be better delineated.[7–9]

The tissue containing CA, includes high-Z radio-opaque materials, attenuates the CT X-rays more than normal. As a result, CT scan with CA causes the temporary increase in the CT number or Hounsfield unit (HU) and so the corresponding electron density (ρ_e).[9,10] Photon dosimetry in radiotherapy is a function of the ρ_e of irradiated tissues; therefore, altering the ρ_e of structures may affect photon dosimetry.

2. Aim

Dosimetric influences caused by using intravenous (IV) and/or oral plus intravenous CA in CT simulation were quantified and the results were examined to determine if these influences were clinically significant. The result may serve as a reference to justify the use of contrast-enhanced CT data sets for three-dimensional conformal radiation therapy (3D-CRT) planning, using DosiSoft ISOgray system, of pelvic region cancers.

3. Materials and methods

3.1. *Patient selection*

We have designed a prospective treatment planning study performed as self-controlled clinical trial with before/after method at Imam Reza Hospital, Kermanshah City, Iran, during the period from April 2015 till July 2015. The ethics committee of Kermanshah University of Medical Sciences (KUMS) approved the patient study (Grant No: kums.rec.1394.12). Also, this trial was registered with the Iranian Registry of Clinical Trials (IRCT) and allocated a unique code (Registration ID: IRCT2015051922319N1). A total of 11 non-metastasized patients (10 male and 1 female), with a mean age of 59.20 ± 14.14 were included in this study. Five patients undergoing radiotherapy for prostate cancer and six patients undergoing rectal irradiation were chosen for the present study. Cases with renal diseases, diabetes, asthma, and prior reactions to CA were excluded. The tumors were staged based on the American Joint Committee on Cancer (AJCC) staging system. Patient characteristics are shown in Table 1.

3.2. *Acquisition of computed tomography (CT)*

Treatment planning CT simulation was performed using a multi slice CT scanner (Aquilion 16 Slice; Toshiba, Japan).

Table 1 – Patient characteristics along with the CA type ($n = 11$).

Patient characteristics		Number of patients	Patients age distribution (year)	
			Median	Mean ± Std dev
Region	*Rectum*	6	45.00	49.20 ± 20.50
T stage	TX	0		
	T1	0		
	T2	3		
	T3	3		
	T4	0		
Lymph node (LN)	LN negative	3		
	LN positive	3		
Gender	Female	1		
	Male	5		
CA	IV	5		
	Oral + IV	1		
Region	*Prostate*	5	65.00	69.20 ± 10.50
T stage	TX	0		
	T1	0		
	T2	1		
	T3	3		
	T4	1		
Lymph node (LN)	LN negative	5		
	LN positive	0		
Gender	Female	0		
	Male	5		
CA	IV	0		
	Oral + IV	5		

Std dev, standard deviation; IV, intravenous.