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CT Taramalarında Absorbe Edilen Dozun Hastanın Boyuna Göre Değişimi

İsmail Hakkı Sarpün[1,2,3], Timur Koca[3], Yasemin Şengün[3], Rahmi Atıl Aksoy[3], Ece Atak[3], Mehmet Kızılkaya[3], Aylin Fidan Korcum[3]

[1]*Akdeniz University, Physics Department, Antalya, Turkey*
[2]*Akdeniz University, Nuclear Sciences Application and Research Center, Antalya, Turkey*
[3]*Akdeniz University, Medicine Faculty, Radiation Oncology Department, Antalya, Turkey*

e-mail: sarpun@akdeniz.edu.tr. ORCID ID:http://orcid.org/0000-0002-9788-699X

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Öz

Kanser tedavilerinde çekilen Bilgisayarlı Tomografi (CT) görüntüleri, tedavi portalı tasarımı ve planlamasında önemlidir. Hastanın CT taramalarında aldığı doz, tedavi planlaması doz hesaplamasında dikkate alınmaz ve kritik doz eşiğine sahip kritik organların sınır dozlarının hesaplanmasında önem kazanır. Bu çalışmada bazı kritik organlar olan kalp, karaciğer ve böbreklerin hastanın boyuna göre aldığı dozun değişimi Monte Carlo tekniği kullanılarak NCICT kodu ile araştırıldı. Sonuç olarak, dozlar hastaların boyuna göre değiştirildi.

Variation of the Dose Taken in CT Scanning According to the Height of the Patient

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Abstract

Computed Tomography (CT) images taken in cancer treatments are important in treatment portal design and planning. The dose received by the patient in CT scans are not considered in the treatment planning dose calculation and becomes important in calculating the limit doses of the critical organs with critical dose threshold. In this study, the change of the dose received by some of the critical organs, namely the heart, liver, and kidneys, according to the height of the patient was investigated with the NCICT code using the Monte Carlo technique. As a result, doses were changed by the height of the patients.

1. Introduction

Despite providing major benefits for patients, CT is source of concern due to its potential radiation dose associated risks, especially for quite susceptible pediatric patients (National Research Council 2006). Epidemiological studies of cancer risk in CT patients require an estimate of the radiation dose absorbed by tissues within the x-ray exposed area (Sechopoulos *et al*. 2015).

Newer CT dosimetry codes have begun to include voxel phantoms (Zaidi and Xu 2007, Xu 2014, Caon 2004). If one compares with previous geometric phantoms, the voxel phantoms are represented more realistic anatomy, which is based on medical tomography images. While, WAZA-ARI, a web-based CT dose calculation system based on an adult male voxel phantom and PHITS code introduced by Ban *et al*. (2011), ImpactDose7, introduced by Kalender *et al*. (1999), is an enhanced version of WinDose, and includes a set of both pediatric and adult voxel phantoms of ICRP (2009). VirtualDoseTMCT is a set of pediatric and adult configurable phantom-based software packages combined with GPU-based Monte Carlo simulation. Sahbaee *et al.* (2014) described a code based on a mathematical model derived from the correlation between coefficients of organ dose and patient body sizes.

Some of the mentioned codes are designed for the calculation of absorbed patient dose in large-scale clinical centers and are available as commercial. Calculation methods, which used in this study, were developed by Lee *et al*. (2015) to evaluate absorbed organ doses for CT patients, by using pediatric and adult reference voxel phantoms adopted by the ICRP and Monte Carlo simulation obtained from x-rays from CT examination.

2. Material and Method

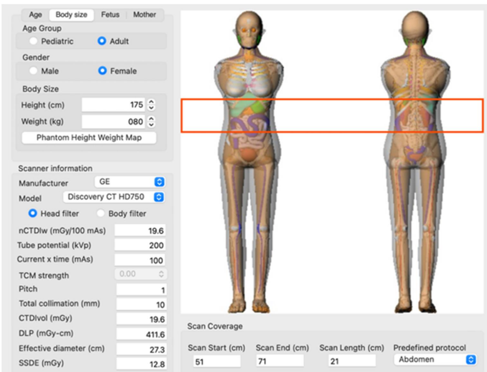
The dose evaluation algorithm used by NCICT is based on the finding reported by Turner *et al*. (2010) that $\mathrm{CTDI_{vol}}$ can be used as

$$D(\text{organ, age, gender,spectrum}) = \sum_{z=SS}^{z=SE} DC(\text{organ, age, gender, spectrum}, z) \times \mathrm{CTDI_{vol}} \quad (1)$$

DC and $\mathrm{CTDI_{vol}}$ parameters were expressed in Zaidi and Xu (2007), Sahbaee *et al.* (2014), Lee *et al.* (2015), Reiser *et al.* (2004), AAPM (2011) and if the $\mathrm{CTDI_{vol}}$ is unknown, it could be evaluated via Eq. (2).

$$\mathrm{CTDI_{vol}}(\text{make, model, spectrum}) = \frac{n\mathrm{CTDI_w}(\text{make, model, spectrum})}{\text{Pitch}} \times \left(\frac{I \times t}{100}\right) \times k_{\mathrm{OB}} \quad (2)$$

Organ absorbed dose per unit air kerma were calculated for Heart Wall, Liver and Kidney for adult female and male phantom (weight constant (80 kg), height variable) (Lee *et al.* 2012, Lee *et al.* 2011, Lee *et al.* 2014). Radiation exposure was simulated by selecting the predefined abdomen as the area for the 200 kV voltage of the irradiation geometry and the current-time value of 100 mAs. Fig. 1 shows the input screen used in the calculation and a female phantom weighing 80 kg with different heights.



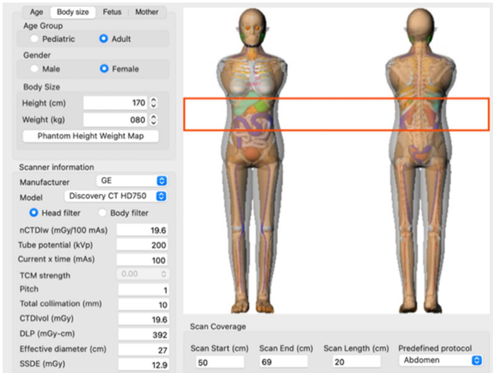


Figure 1. Female phantom weighing 80 kg with different heights

3. Calculations

By using phantoms (both male and female) weighing 80kg and different heights, the predefined abdominal region CT shots were simulated by selecting 200 kV tube voltage and 100 mAs current-time constant for a scanner most similar to the CT scanner in our clinic. Organ doses were calculated for Heart Wall, Liver and Kidney, which were determined as critical organs in the region. The variation of organ doses according to the phantom size is shown in Figs. 2 and 3.

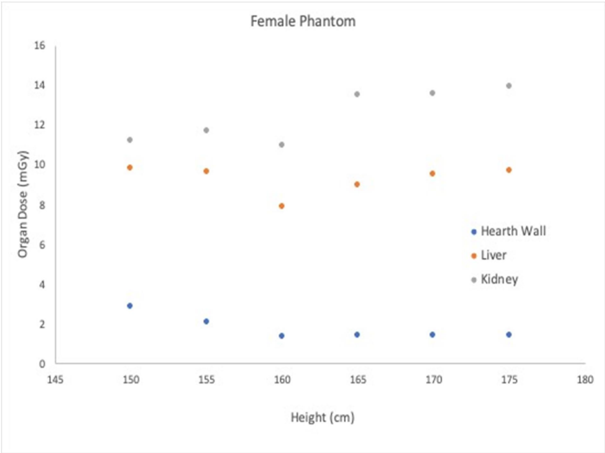


Figure 2. Variation of organ doses by height for 80 kg female phantom.

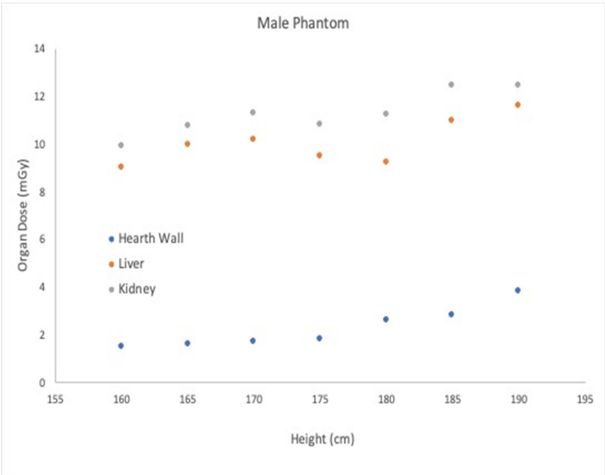


Figure 3. Variation of organ doses by height for 80 kg Male phantom.

The effective doses obtained by the same calculation are shown in Fig. 4.

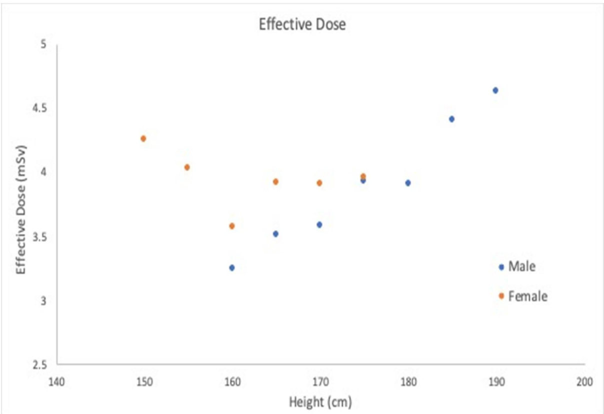


Figure 4. Variation of effective dose by height for both female and male phantoms.

4. Conclusion

The effective dose of the shot was calculated with Heart Wall, Liver and Kidney organ doses for both male and female phantoms with a mass of 80 kg and of different heights by using Monte Carlo-based NCICT code, with a tube voltage of 200 kV and a current-time value of 100 mAs in the pre-defined abdomen region irradiation in CT. Although organ doses for both phantoms increase with increasing height, when the effective doses are examined, despite the same relation being observed for the male phantom, there are irregularities in the values of the female phantom. Upon examination of organ doses and effective doses, irregular results are obtained with a length of 160 cm for the female phantom and a length of 175 cm for the male phantom. The obtained data will be beneficial for users employing ICRP phantoms for Monte Carlo dose calculation to compare the calculation process.

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