RESEARCH ARTICLE / Araştırma Makalesi

Comparison Of Computed Tomography Dose İndices For Single Energy And Fast Kilovoltage Switching Dual Energy Abdominal Computed Tomographies

Tek Enerji ve Hızlı Voltaj Değişimli Çift Enerji Abdomen Bilgisayarlı Tomografilerine Ait Bilgisayarlı Tomografi Doz İndekslerinin Karşılaştırılması

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Abstract

Objective To investigate the computed tomography dose index (CTDI) of the single source fast kilovoltage-switching dual energy CT (SS FKS-DECT) of the abdomen compared to those of conventional single source single energy (SSSE) CT. **(Sakarya Med J 2018, 8(1):41-45)**

Materials and Methods In this methodological research, the mean CTDI of the SS FKS-DECT of the abdomen obtained from 73 patients (32 women and 41 men) with a mean age of 52±15.7 years, compared to the CTDI of the conventional SSSE CT. Body mass indices (BMI) of all patients and CTDI of all scans were noted. Two-tailed student t test was used for statistical analysis. A P value of <0.05 was considered as statistically significant.

Results The mean BMI was 24.2±7.6 and the mean CTDI for the FKS-DECT and SECT were 14.6±2.5 mGy and 12.5±7.2 mGy, respectively. The difference between the CTDI values of both acquisitions were statistically significant (p=0.02). The mean CTDI of the FKS-DECT of the abdomen was14.4% higher than those for the SECT. .

Conclusion The mean CTDI of the SS FKS-DE abdomen CT was 14.4% higher than those of the SS SE abdomen CT.

Key words: Dual energy, Abdominal CT, CT, Dual energy CT

Öz

Amaç Tek kaynaklı tek enerji (TK TE) ve tek kaynaklı hızlı voltaj değişimli çift enerji (TK HVD-ÇE) abdomen bilgisayarlı tomografilerine (BT) ait BT doz indekslerini (BTDİ) karşılaştırmak. **(Sakarya Tıp Dergisi 2018, 8(1):41-45).**

Gereç ve Yöntemler Bu metodolojik çalışmada, yaş ortalaması 52±15,7 yıl olan 73 hastadan (32 Kadın ve 41 Erkek) elde olunmuş HVD-ÇE abdomen BT'lere ait ortalama BTDİ, TE abdomen BT'lere ait ortalama BTDİ'ler ile karşılaştırıldı. Tüm hastaların vücut kitle indeksleri (VKİ) ve BT taramalarına ait BTDİ'leri kaydedildi. İstatistiksel analiz için örneklem t testi kullanıldı. P değeri <0.05 istatistiksel olarak anlamlı kabul edildi.

Bulgular Ortalama VKİ 24.2±7.6 ve HVD-ÇEBT ile TEBT'lere ait ortalama BTDİ değerleri sırasıyla 14.6±2.5 mGy ve 12.5±7.2 mGy idi. Her iki teknik ile elde olunan ortalama BTDİ'ler arasındaki fark anlamlıydı (p=0.02). HVD-ÇE abdomen BT'ye ait ortalama BTDİ, TE abdomen BT'ye göre %14.4 daha fazla idi.

Sonuç: HVD-ÇE abdomen BT'ye ait ortalama BTDİ, TE abdomen BT'ye göre %14.4 daha fazla idi.

Anahtar kelimeler: Çift enerji, Abdomen BT, BT, Çift enerji BT

Introduction

Dual energy computed tomography (DECT) is a relatively new technological development and different vendors provide different techniques in order to obtain dual energy (DE) images. DECT utilizes two different energy levels for the same slice and therefore, it can enable differentiation of different tissues and materials like urinary stones.[1] The major advantage of DECT is availability of virtual non-contrast (water) images in every patient.[2] There are several more advantages of DE for the abdominal applications including increased tissue contrast, diagnosis of calcification or hemorrhage within lesions and differentiation of polyp/mass from stool.

DECT can be performed by dual source, single source fast kilovoltage-switching (FKS), and single source dual layered detector CT.[3, 4] In single source FKS-DECT, the tube voltage changes rapidly in an approximately 0.25 msn and there was no time delay.[5] Although there are many benefits of DECT, the radiation dose levels are controversial and differs from technique to technique, and have been searched in many studies in the literature. However, the radiation dose of the FKS-DE abdominal CT is remained to be identified.

In the current study, we aimed to investigate the CT dose indices (CTDI) of the single source (SS) FKS-DECT of the abdomen compared to those of conventional SS single energy (SSSE) CT.

Materials and Methods

Patient population

The local Institutional Review Board (IRB) approved the current study and written informed consent was obtained from all patients. The study was designed according to the International Helsinki Declaration. Abdominal CT of the patients obtained with FKS-DECT between 1 October 2016 and 1 April 2017, were enrolled in this methodological research. 49 patients (23 women and 26 men) had abdominal CT for routine oncological evaluation and follow-up and, 24 (9 women and 15 men) patients had abdominal CT for the detection of urinary stones.

Single energy (SE) and dual energy CT techniques

All CT scans were performed with a 128-slice multi-detector CT (Revolution CT GSI; GE Healthcare, Milwaukee, Wis.). Patients were placed in supine position on the CT table and scanned in cranio-caudal direction. Routine abdominal CT protocol in our institute was performed as venous phase imaging of the abdomen, 65-70 s after the administration of 80-120 ml non-iodinated contrast material with a flow-rate of 3-4 ml/s from the antecubital vein, followed by 30 ml saline injection. Bolus-tracking technique was used for all CT scans. The following CT parameters were same for all DE scans: collimation; 40x0.625 mm, rotation time; 0.6 ms, Pitch; 1.375, tube potential; 80-140 kVp, miliamper; 275-630 mA, matrix; 512x512, slice thickness 0.625 mm (Table 1).

After taking the scout image and before the DE scan, SE abdomen CT mode was opened on the CT console and all CT parameters were selected to be identical with the DE mode. Then, the CTDI given by the machine before the acquisition was noted without completing the scan. All of the CT parameters and the CTDI for both acquisitions were recorded. Body mass indices (BMI) of all patients were also calculated.

Table 1. CT parameters for the single energy and fast-kilovoltage switching dual energy acquisitions		
	CT Acquisition	
CT Parameter	SECT	FKS DECT
Collimation	40x0.625 mm	40x0.625 mm
Rotation time	0.6 ms	0.6 ms
Pitch	1.375	1.375
Tube voltage	120 kVp	40-140 kVp
Tube current	AEC	275-630 mA
Matrix	512x512	512x512
Slice thickness	0.625 mm	0.625 mm
Contrast volume	80-120 mL	NA
Injection rate	3 mL/s	NA
CT; computed tomography, SECT; single energy CT, FKS DECT; fast kilovoltage switching dual energy CT, NA; non-applicable		

Statistical analysis

To compare the CTDI of both acquisitions, the paired Student's t test was used. Descriptive statistics were expressed as means±standard deviations. P<0.05 was considered as statistically significant. All statistical analysis was performed using IBM SPSS version 21 (SPSS Inc., Chicago, IL, USA).

Results

A total of 73 patients with a mean age of 52±15.7 years (range: 19-85 years) were enrolled in the current study. There were 32 women and 41 men.

The mean BMI was 24.2±7.6 and the mean CTDI for the SECT and FKS-DECT were 12.5±7.2 mGy and 14.6±2.5 mGy, respectively (Table 2). The difference between the CTDI values of both acquisitions were statistically significant (P=0.02). The mean CTDI of the FKS-DECT of the abdomen was 14.4% higher than those for the SECT. The mean CTDI for 38 patients with BMI≤25 were 9.8±4.3 mGy vs 11.8±13.7 for the SECT vs FKS-DECT (P=0.186). The mean CTDI for 35 patients with BMI>25 were 16.1±7.8 mGy vs 13.1±6.1 for the SECT vs FKS-DECT (P=0.996) (Table 2).

Table 2. The mean CTDI for SECT and FKS-DECT			
Parameter	SECT	FKS DECT	P value
CTDI	12.5±7.2 mGy	14.6±2.5 mGy	0.002
CTDI in patients with BMI≤25	9.8±4.3 mGy	11.8±13.7 mGy	0.186
CTDI in patients with BMI>25	16.1±7.8 mGy	13.1±6.1 mGy	0.996
CTDI; computed tomography dose index, SECT; single energy CT, FKS DECT; fast kilovoltage switching dual energy CT			

Discussion

The current study demonstrated that the mean CTDI of the FKS-DE abdominal CT was 14.4% higher than those of the SECT. And this difference was statistically significant. Uhrig et al6 found no significant difference between the mean CTDI of SE and DE abdominal CTs. However, their scanner was a dual source DECT and the patients were not the same and some patients underwent DECT, some patients underwent SECT with different CT parameters. However, in the current study, all of the patients and the CT parameters were same for both acquisitions.

Purysko et al7 reported significantly lower CTDI values for DECT compared to SECT in patients having hepatocellular carcinoma screening by using dual source DECT. Ho LM et al8 found the mean CTDI of FKS-DECT 32.8% higher than the SECT for abdominal imaging. Li B9 showed that the CTDI of the FKS-DECT was 14% higher than the SECT of the abdomen in a phantom study. Lin et al10 found slightly higher CTDI values for the FKS-DECT than SECT in patients with preoperative assessment of insulinomas. The reason for higher CTDI in FKS-DE abdominal CT than dual source DECT could be explained by the fixed tube current along the whole scan length because FKS-DECT could not use an automatic exposure control and therefore, the CTDI and as a result the radiation dose remained high with respect to the dual source DE systems. However, in FKS-DECT, the exposure times could be changed between the different energy levels in order to overcome the radiation dose increase. In other words, for the low tube voltage, the exposure time was longer and for the high tube voltage the exposure time was shorter.9 This is a radiation saving compensatory feature of this techique.

Radiation dose levels for the FKS-DECT was higher than the SECT however, with the availability of virtual non-contrast (water) images, which is a post-processing technique, the radiation dose could be decreased and the pre-contrast imaging of the abdomen might be skipped.8 This critical point must be kept in mind when the radiation doses of SE and DE abdominal CT protocols were compared.

We also found that the CTDI of the SE abdominal CT increased more than those of the DE abdominal CT with increasing BMI. This was secondary to automatic exposure control property of SECT, because automatic exposure control increases the tube current and also the radiation dose with respect to the patient thickness. And therefore, for the large patients or patients with BMI>25, the use of FKS-DECT becomes advantageous in terms of radiation dose. On the other hand, for patients with BMI≤25, FKS-DECT with the fixed tube current, offered 13.6% higher CTDI values than those of SECT. As a result, FKS-DE abdominal CT might be used carefully in patients with BMI≤25 because of the radiation burden.

There were several limitations in our study. First of all, we used the CTDI values of the SECT from the CT console for comparison and this might underestimate the accurate CTDI of the SECT which was obtained after the actual scan. Secondly, the image noise, contrast, contrast to noise and signal to noise ratios were not compared. Finally, the number of the patients remained low and studies with larger number of patients are necessary to conclude reliable and reproducible results. In conclusion, the mean CTDI of the SS FKS-DE abdominal CT was 14.4% higher than those of the SS SE abdominal CT. However, in obese and overweight patients, it might be advantageous to utilize FKS-DECT in terms of radiation dose.

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