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EVALUATION OF THE COMPATIBILITY OF ATRIUM AND VENTRICULAR MEASUREMENTS IN THORACIC COMPUTERIZED TOMOGRAPHY AND CORONARY COMPUTERIZED TOMOGRAPHY ANGIOGRAPHY

Toraks Bilgisayarlı Tomografi ve Koroner Bilgisayarlı Tomografi Anjiografide Atriyum ve Ventrikül Ölçümlerin Uyumluluğunun Değerlendirilmesi

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Abstract

Aim: We aimed to evaluate the consistency of the measurements of diameter and area of cardiac chambers in coronary computed tomography angiography (CTA) and contrast-enhanced thoracic computed tomography (CT) images.

Materials and Methods: 30 patients who underwent thoracic CT and coronary CTA over a 6-month period between August 2016 and August 2019 were included in the study. Maximum left atrium area, anteroposterior and transverse left atrium diameter, right atrium transverse diameter, right and left ventricular transverse diameters were measured by two observers. Inter-observer and intra-observer Contrast-enhanced thoracic CT and coronary CTA measurements of the cardiac chambers were found to be perfectly compatible. Both left atrial axial area and AP diameter were evaluated on coronary CTA images and contrast-enhanced thoracic CT with excellent reproducibility.

Conclusion: To our knowledge, this is the first study that shows the measurement of diameter and area of the cardiac chambers in thoracic CT and coronary CTA and comparing them with each other. Thoracic CT, with its high reproducibility, could be a useful tool in evaluation of cardiac chambers.

Keywords: Thoracic computed tomography; cardiac chamber; coronary computed tomography angiography.

Öz

Amaç: Bu çalışmada koroner bilgisayarlı tomografi anjiyografi (BTA) ve kontrastlı toraks bilgisayarlı tomografi (BT) görüntülerinde kalp odalarının çap ve alan ölçümlerinin tutarlılığını değerlendirmeyi amaçladık.

Materyal ve Metot: Ağustos 2016 ile Ağustos 2019 tarihleri arasında 6 aylık bir süre içerisnde torasik BT ve koroner BTA ile tetkik edilen 30 hasta çalışmaya dahil edildi. Maksimum sol atriyum alanı, ön-arka ve transvers sol atriyum çapı, sağ atriyum transvers çapı, sağ ve sol ventrikül transvers çapları iki gözlemci tarafından ölçüldü. Gözlemciler arası ve gözlemci içi uyum, sınıf içi korelasyon katsayıları kullanılarak hesaplandı.

Bulgular: Kalp odacıklarının kontrastlı toraks BT ve koroner BTA ölçümlerinin mükemmel uyumlu olduğu bulundu. Hem sol atriyal aksiyal alanı hem de ön-arka çapı, koroner BTA görüntülerinde ve toraks BT'de yüksek tekrarlanabilirlik ile değerlendirildi.

Sonuç: Bildiğindiği kadarı ile bu çalışma, toraks BT ve koroner BTA'da kalp odalarının çapının ve alanının ölçümünü ve birbirleriyle karşılaştırılmasını gösteren ilk çalışmadır. Yüksek tekrarlanabilirliği ile toraks BT, kalp odacıklarının değerlendirilmesinde yararlı bir modalite olabilir.

Anahtar Kelimeler: Toraks bilgisayarlı tomografi, kalp odası, koroner bilgisayarlı tomografi anjiyografi.

INTRODUCTION

Non-electrocardiography-gated thoracic computed tomography (CT) plays an important role in the evaluation of emergency and routine thoracic pathologies. Although the heart is always in the imaging field on thoracic CT and many cardiac findings can be evaluated with thoracic CT, the report does not usually include a detailed assessment of the heart [1,2].

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Thoracic CT can be used to evaluate the enlargement of the cardiac cavities and the values found by simple linear axial measurements have been shown to be consistent with the results of transthoracic echocardiography (TTE) [3]. Thoracic CT can detect many cardiac entities such as coronary artery calcifications and anomalies, myocardial disease, pericardial effusion, and expansion of cardiac chambers [4]. Apart from incidental cardiac pathologies, contrast-enhanced thoracic CT may be useful in the evaluation of cardiac pathologies in emergency imaging and in centers where advanced imaging techniques are not available. In pulmonary hypertension, heart failure and ischemic heart disease, it is important to detect the enlargement of the cardiac chambers [5-6]. On the other hand, there are limitations due to motion artifacts in the evaluation of cardiac pathologies and coronary arteries by thoracic CT. For this reason, electrocardiography (ECG) triggered coronary computed tomography angiography (CTA) has been developed.

Dilatation of cardiac chambers has been shown to be an important biomarker for predicting morbidity and mortality for cardiovascular events such as atrial fibrillation, myocardial infarction, stroke, and heart failure. [7-11]. Left atrial dilatation is an important parameter in predicting cardiovascular events, especially since the left atrial size is used in risk stratification of individuals with and without cardiovascular disease [12-14].

TTE, magnetic resonance imaging (MRI) and coronary CTA have been used to evaluate the dimensions of cardiac cavities and cardiac MRI has been defined as the gold standard method [15]. In different studies in the literature, normal reference values and threshold values for identifying enlarged cardiac chambers are specified [16-17]. However, contrast-enhanced thoracic CT, which is frequently used in daily practice, may be useful in the evaluation of cardiac cavities. Although the use of non-ECG-gated multi-detector thoracic CT is widely used all over the world and a common consensus has been achieved in the evaluation of heart size in this examination, the evaluation of cardiac cavities has not been standardized yet.

The aim of this study was to evaluate the consistency of the measurements of diameter and area of cardiac chambers in coronary CTA and contrast-enhanced thoracic CT examinations.

MATERIAL AND METHODS

Our study was approved by the Local Ethics Committee. Patients who underwent contrast-enhanced thoracic CT and coronary CTA over a 6-month period at the Department of Radiology between August 2016 and August 2019 were retrospectively reviewed. Thirty of 46 patients were included in the study. 16 patients were excluded from the study. Nine of these 16 patients were not suitable for evaluation because of poor image quality and insufficient contrast filling. ECG synchronization was not performed in 7 patients.

Technical data

Thoracic CT and coronary CTA 64-section double-tube CT (SOMATOM Definition, Siemens Medical Solutions, Forchheim, Germany) was used in all patients.

Thoracic CT protocol

The standard protocol (120 kVp, auto-mA- maximal 350 mA) was used for thoracic CT scans. CT images were obtained during a single breath hold at the end of the inspirium. 70 ml of contrast medium (Omnipaque, Amersham Health, Cork, Ireland) were injected antecubitally at a rate of 3 ml / sec.

1.25 mm collimation, 400 milliseconds (msec) rotation, 1.35 pitch, 120 kV and 400–480 milliamps / second (ingredi) in X-ray tube, 1.25 mm section thickness and 2.5 mm reconstruction interval parameters were used. The field of view (FOV) was adjusted to the size of the patient and a 512 x 512 matrix was used.

Coronary CTA protocol

In all patients, ECG electrodes were connected and rhythm and heart rates were checked before scanning. 70-75 ml contrast agent (Omnipaque, Amersham Health, Cork, Ireland; 5cc / sec followed by 50cc 0.9% saline 5 cc / sec) was given antecubitally with the help of an automatic injector (Ulrich, Germany). Slices were taken for volume coverage from the carina to the diaphragm. 0.5 mm collimation, 400 milliseconds (msec) rotation, 0.275: 1–0.3: 1 pitch, 120 kV and 400–480 milliamps / second (kals) in the X-ray tube, 24 cm FOV, 0.5 mm section thickness; and 0.3 mm reconstruction interval parameters were used. Patients with heart rate above 75 beats / min were started on oral beta blockers and after the patients' heart rate reached the appropriate range, they were examined. Imaging was successfully completed without any complication. Retrospective ECG triggering method was used.

Image Analysis

The cardiac chamber measurements of the patients included in the study were performed by two radiologists with 12 years and 4 years of professional experience in thoracic CT and coronary CTA. Both radiologists were unaware of each other's results when making measurements. After both radiologists performed the measurements separately, the first radiologist did all the measurements again after 15 days. Measurements were made using picture archiving and communication system (PACS).

In order to make a clear distinction between the heart wall and blood pool, all examinations were performed on contrast-enhanced images. Contrast-enhanced thoracic CT with insufficient contrast filling to prevent measurement was not included in the study.

Maximum left atrial area, anteroposterior and transverse diameter of the left atrium, transverse diameter of the right atrium, and transverse diameter of the left and right ventricle were calculated on both contrast-enhanced thoracic CT and coronary CTA.

Measurements in 3-dimensional volumetric imaging in both modalities were not evaluated because they were time consuming and difficult to use in routine practice.

Left Atrial Area, Anteroposterior and Transverse Diameter Measurements in Thoracic CT and Coronary CTA

Axial sections were used for maximum left atrial area measurement. Measurements were made at the left ventricular outflow tract level and visually at the widest section. The measurement result was calculated in mm^2 (Figure 1). Anteroposterior and transverse diameters of the left atrium were measured at the axial plane with the maximum diameter without participation of the pulmonary veins and the left atrial appendage

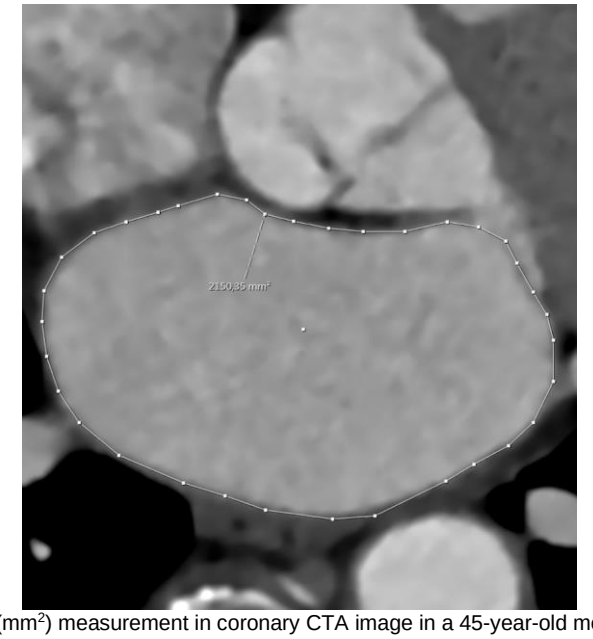

Figure 1. Left atrium axial area (mm^2) measurement in coronary CTA image in a 45-year-old men.

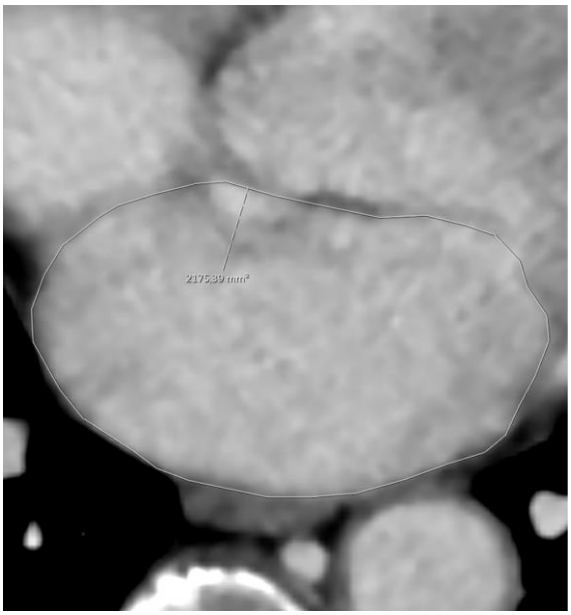

Figure 2. Left atrium axial area (mm2) measurement in contrast-enhanced thoracic CT image in the same patient.

Measurement of Left Ventricular Transverse Diameter in Thoracic CT and Coronary CTA

The largest diameter of the left ventricle was measured at the mid-ventricular level in the transverse plane perpendicular to the lateral wall from the septum.

Measurement of Right Ventricular Transverse Diameter in Thoracic CT and Coronary CTA

At the mid-ventricular level, the largest diameter of the right ventricle was measured perpendicular to the lateral wall in the transverse plane.

Transverse Diameter Measurement of Right Atrium in Thoracic CT and Coronary CTA

Right atrial diameter was measured using the maximum distance between the interatrial septum and lateral wall on axial images.

Statistical analyses

Statistical data analysis Statistical Package for Social Science (SPSS, version 20.0) package program was used to evaluate the findings. Descriptive statistical methods (mean, standard deviation) as well as Student's t test were used to show the differences in measurements.

Statistical significance was accepted at a P value of less than 0.05. Inter-observer and intr-observer agreement in the quantitative analysis were calculated using intraclass correlation coefficients (ICCs) from a one-way random effects model analysis of variance, with the subject as the random effect. A 95% confidence interval (CI) was constructed for each ICC. An ICC greater than 0.80 indicated excellent agreement. Correlations between variables were evaluated using Pearson's correlation coefficient value.

RESULTS

In the study consisting of 30 patients, 16 (53.3%) were male and 14 (46.6) were female. Mean age and standard deviation of the patients were calculated as 57.9 ± 14.6 years. The youngest patient was 25 years old and the oldest patient was 84 years old (Table 1). The average time interval between the two examinations was 50.5 days.

Table 1. General characteristics of study population

Patients	30
Age (mean ± SD)	57,9 ± 14,6
Age range	25-84
gender	14 M
	16 F

M: male
F: female
SD: Standard deviation

The cardiac chamber measurements of the patients in thoracic CT and coronary CTA are summarized in Table 2. The left atrial area was 2182.6 ± 562 mm^2 and 2220 ± 543 mm^2 for the first and second observer on CT, and 2161 ± 6 mm^2 and 2152 ± 592 mm^2 in coronary CTA, respectively. The diameter of the left atrial AP was 39.6 ± 8 mm and 40.3 ± 7.7 mm for the first and second observer on thoracic CT, and 39.3 ± 8 mm and 40.5 ± 7.8 mm, on coronary CTA, respectively. The left atrial transverse diameter was 66.6 ± 7.6 mm and 65.6 ± 7.5 mm for the first and second observer on the thoracic CT, respectively, and 65.3 ± 7.8 mm and 64.5 ± 7.6 mm in the coronary CTA, respectively. The right atrial transverse diameter was 53.8 ± 10.2 mm and 53.6 ± 7.8 mm for the first and second observer on thoracic CT, and 54.2 ± 9.1 mm and 53.3 ± 6.9 mm, on coronary CTA respectively. The left ventricular transverse diameter was 47.9 ± 9.3 mm and 47.7 ± 9.5 mm for the first and second observer on the thoracic CT, and 47.1 ± 9.1 mm and 45.6 ± 8.9 mm on the coronary CTA, respectively. Right

ventricular transverse diameter was 44.3 ± 5.3 mm and 44.2 ± 6 mm for the first and second observer on the thoracic CT, and 44.6 ± 6.3 mm and 44.4 ± 6.7 mm, in the coronary CTA respectively.

In order to demonstrate intraobserver and interobserver reproducibility, the measurements of the left atrium area and left atrial AP diameter measurements of the first and second observers and both measurements of the first observer were evaluated.

On contrast-enhanced thoracic CT, both the left atrial axial area and AP diameter had excellent reproducibility. (Interobserver axial area: ICC 0.957, mean relative difference 0.913-0.980, AP diameter: ICC 0.943, 0.884-0.972; Intraobserver axial area: ICC 0.964, 0.927-0.983, AP diameter: ICC 0.963, 0.924-0.982).

Both left atrial axial area and AP diameter were evaluated with excellent reproducibility on coronary CTA images. (Interobserver axial area: ICC 0.945, mean relative difference 0.888-0.974, AP diameter: ICC 0.939, 0.875-0.970; Intraobserver axial area: ICC 0.971, 0.940-0.986, AP diameter: ICC 0.959, 0.913-0.980).

Table 2. Statistical results of thoracic CT and coronary CTA measurements of patients

		Reader 1 (mean ± SD)	Reader 2 (mean ± SD)
Left atrium area (mm^2)	Thoracic CT	2182.6 ± 562	2220 ± 543
	Coronary CTA	2161 ± 6	2152 ± 592
Left atrium AP diameter (mm)	Thoracic CT	39.6 ± 8	40.3 ± 7.7
	Coronary CTA	39.3 ± 8	40.5 ± 7.8
Left atrium transverse diameter (mm)	Thoracic CT	66.6 ± 7.6	65.6 ±7.5
	Coronary CTA	65.3 ± 7.8	64.5 ± 7.6
Right atrium transverse diameter (mm)	Thoracic CT	53.8 ± 10.2	53.6 ± 7.8
	Coronary CTA	54.2 ± 9.1	53.3 ± 6.9
Left ventricle transverse diameter (mm)	Thoracic CT	47.9 ± 9.3	47.7 ± 9.5
	Coronary CTA	47.1 ± 9.1	45.6 ± 8.9
Right ventricle transverse diameter (mm)	Thoracic CT	44.3 ± 5.3	44.2 ± 6
	Coronary CTA	44.6 ± 6.3	44.4 ± 6.7

SD: standard deviation
AP: anteroposterior
CTA: computed tomography angiography
CT: computed tomography

Correlation coefficients for intraobserver and interobserver reproducibility of measurements of cardiac chambers in thoracic CT and coronary CTA are shown in Table 3.

Table 3. Interobserver and intraobserver variability in coronary CTA and thoracic CT measurements

		Reader 1 (first measurement) (mean ± SD)	**Reader 1 (second measurement) (mean ± SD)**	**Reader 2 (mean ± SD)**	**Interobserver ICC**	**Intraobserver ICC**
Left atrium area (mm^2)	tCT	2182.6 ± 562	2282 ± 560	2220 ± 543	0,957 (0,913-0,980)	0,964(0,927-0,983)
	cCTA	2161± 6	2188 ± 638	2152 ± 592	0,945(0,888-0,974)	0,971(0,940-0,986)
Left atrium AP diameter (mm)	tCT	39.6 ± 8	40.2 ± 7.9	40.3 ± 7.7	0,943(0,884-0,972)	0,963(0,924-0,982)
	cCTA	39.3 ± 8	40.9 ± 8.2	40.5 ± 7.8	0,939(0,875-0,970)	0,959(0,913-0,980)

SD: standard deviation
AP: anteroposterior
cCTA: coronary computed tomography angiography
tCT: thoracic computed tomography
ICC: Intraclass Correlation Coefficients

DISCUSSION

As a result of our study, it was shown that the measurements of cardiac chambers in coronary CTA and non-ECG-gated, unreformed contrast-enhanced thoracic CT are perfectly compatible with each other. In the literature, there are several studies evaluating the dimensions of the heart chambers with coronary CTA [18-19] or with non-ECG-gated thoracic CT [20]. However, in the English literature review, there was no study which was measured the diameter and area of the cardiac chambers in thoracic CT and coronary CTA and comparing them with each other. This is the first study comparing the measurements in these modalities and showing the consistency between the measurements.

Cardiac enlargement in thoracic CT, which is used frequently in routine and emergency practice, can be evaluated as consistent with coronary CTA. In cardiac reports, many cardiac entities may be detected by routine cardiac examination, which is often overlooked by radiologists. Comparative studies with echocardiography and cardiac MRI will determine the quantitative values and will increase the use of thoracic CT in cardiac examinations.

Thoracic CT is superior to coronary CTA, as there is no need for patient preparation and special equipment before the examination, detection of non-cardiac pathologies, and wider imaging area. Cardiac and respiratory motion artifacts and insufficiency of intravascular (IV) contrast agent due to examination phase are among the limitations of thoracic CT [4,6].

In our study, correlation coefficients were found to be excellent for intra- and inter-observer reproducibility of measurements of cardiac chambers in thoracic CT and coronary CTA. Pearson correlation analysis revealed significant correlation between left atrial area and AP diameter ($r = 0.84$; $p < 0.001$) in thoracic CT and left atrial areas in thoracic CT and coronary CTA ($r = 0.82$; $p < 0.001$). In addition, the left atrial transverse diameter in the coronary CTA was significantly correlated with the left atrial area ($r = 0.83$; $p < 0.001$) and left atrial AP diameter ($r = 0.66$; $p < 0.001$).

Our study has some limitation factors. Firstly, even if there is an average of 50.5 days between the two modality, this period may lead to alteration of cardiac chambers as a result of remodeling in the heart and may cause inconsistencies in measurementsSecondly, the number of patients is small and studies in larger patient groups may show effective results. Finally, in our study, we did not compare the measurements of thoracic CT and coronary CTA with TTE or cardiac MRI. In the literature review, several studies were performed in order to define the enlargement of cardiac chambers on non-ECG-gated thoracic CT and these measurements were compared with TTE or cardiac MRI results [3,20-22]. Studies comparing thoracic CT and coronary CTA measurement results with these modalities will reveal more clearly the consistency between the modalities used in our study. In conclusion, evaluation of cardiac chambers can also be performed on non-ECG-gated thoracic CT, and interpretation of cardiac chambers in routine thoracic CT reports can be added to the report.

Conflict of interest

None.

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