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ORIGINAL ARTICLE

Role of Multidetector Computed Tomography Coronary Angiography in Delineating the Normal Anatomy of the Coronary Venous System.

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ABSTRACT

Background: The coronary venous system is a commonly used route of entry to the heart. It is being used increasingly for various electrophysiological purposes, as cardiac resynchronization therapy (CRT) in treating arrhythmias and heart failure. Multi-detector Computed Tomography (MDCT) coronary angiography is an excellent non-invasive modality in visualizing cardiac veins anatomy as well as being an alternative tool for invasive retrograde cardiac venography.

This study aimed to delineate the normal anatomy of the coronary venous system before CRT using MDCT coronary angiography with multi-planar reformation (MPR) and three-dimensional (3D) reconstruction.

Methods: The study was done in Zagazig university hospitals in the period from June 2019 to February 2020. Thirty patients with normal heart rate were enrolled (60% males and 40% females; mean age: 55.87±12.02 years, range: 26–71 years), who underwent elective MDCT coronary angiography using 128-slice MDCT scanner (Ingenuity Phillips health care, best Netherlands).

Results: The systolic phase of cardiac cycle (45%) was the best phase where most cardiac veins were best seen. Coronary Sinus (CS), Great Cardiac Vein (GCV), Anterior Interventricular Vein (AIV) and Middle Cardiac Vein (MCV) were visualized in all cases (100%). Thebesian valve was observed in (73%). The diameter of the CS ostium in the superoinferior direction (mean 17.2 ± 2.55) was significantly larger than that in the anteroposterior direction (mean 12.58 ± 2.44).

Conclusions: This study showed that MDCT coronary angiography is a promising imaging modality in the delineation of cardiac veins anatomy. Also, it can offer information about their relationship with adjacent anatomical structures.

Keywords:
Coronary venous system, Thebesian valve, Coronary sinus, Cardiac resynchronization therapy, MDCT coronary angiography.

INTRODUCTION

The coronary venous network is composed of four constant veins, i.e., coronary sinus: middle cardiac vein, great cardiac vein, and anterior interventricular vein. The coronary veins run along with the coronary arteries in the interventricular grooves and are well visible on computed tomography **[1, 2]**.The function of the cardiac veins was not evaluated for many years. A variety of percutaneous cardiology procedures have been developed over the last 20 years with the significance of cardiac veins anatomy. Cardiac resynchronization therapy appears to be the most important procedure and is an invasive tool for heart failure treatment **[3].** In several electrophysiological purposes such as radiofrequency catheter ablation, defibrillation, mapping, percutaneous mitral annuloplasty, local medication deliveries, and cardiac resynchronization therapy (CRT), the cardiac venous system is progressively being used **[4].**

Retrograde cardiac venography has been the gold standard technique for defining coronary venous anatomy; nevertheless, it is invasive, technically hard, and unable to determine the relations between the coronary arteries and coronary veins **[5, 6].** At present, venous anatomy evaluation is not carried out on a routine basis. Because cardiac venography is an invasive method, a non-invasive imaging technique such as multidetector CT Coronary angiography (CTA) may offer initial venous mapping before a cardiac device is placed

[7, 8]. Coronary CTA is an effective technique to visualize coronary arteries in a non-invasive way that can also give knowledge about heart champers anatomy, valves, and ventricular activity. It allows the examination of the left atrium, pulmonary veins, and cardiac veins, also known as' venous mapping' **[9]**. Coronary CTA examination before CRT gives a detailed non-invasive evaluation of the anatomy of the cardiac venous network, the coronary sinus caliber, the size, and course of the coronary veins subject to catheterization and electrode stimulator implantation. This examination can exclude the potential existence of anatomical problems which may hinder the device's accurate placing. In the same acquisition done for the examination of coronary arteries, this finding is obtained without any extra scanning time and consequently no more dosage of contrast or X-ray to the patient **[10].**

The aim of the study was to assess the role of multidetector computed tomography (MDCT) coronary angiography in delineating the normal anatomy of the coronary venous system with multiplanar reformation (MPR) and three-dimensional (3D) reconstruction before Cardiac Resynchronization therapy.

METHODS

Patients: This study was carried out at Radio-diagnosis department, Zagazig university hospitals. A total number of 30 patients with normal heart rate were scheduled for elective multidetector CT coronary angiography in the period from June 2019 to February 2020. They were 18 males (60%) and 12 females (40%), their age ranged from 26 to 71 years (mean age= 55.87 years ±12.02). The patients were referred by a physician for suspicion of having coronary artery disease or before cardiac resynchronization therapy. We retrospectively evaluated them for the cardiac venous system.

Inclusion Criteria: Our study enrolled adult patients of both sexes who were referred to coronary CT angiography, patients with suspected coronary heart disease or patients prepared for cardiac resynchronization therapy.

Exclusion Criteria: Patients with either absolute contraindications (Patients with elevated renal functions (GFR<30ml/min) but not on dialysis, contraindications to contrast media, Pregnancy, morbid obesity) or relative contraindications (renal diseases on dialysis, hemodynamic instability, patients with irregular heart rate, inability to maintain adequate inspiratory breath-hold during the scan) were excluded from the study.

Full history was taken. Revision of previous laboratory and other cardiac investigations was done prior to MDCT examination. The study was approved by the research ethical committee of Faculty of Medicine, Zagazig University, and the study was done according to the code of ethics of the world medical association (Declaration of Helsinki) for studies involving humans.

Patient preparation: The patient was asked to fast for 4 hours before the examination, but medications are not to be discontinued (apart from metformin is stopped by 48 hours before examination). Heart rate was controlled to be kept about 65 beats per minute (Beta–blockers administration one day before examination). Respiration training was done to hold breath for 12 seconds. Then the I.V route was applied in right ante-cubital vein followed by proper positioning of ECG leads for simultaneous acquisition of both the patients ECG tracing and the CT data.

Image acquisition

A retrospective ECG gated CTA technique was achieved during single breath-hold using 128 multi-detectors (Ingenuity Phillips health care, best Netherlands) scanner as follows: Scanogram, after that contrast media is given using bolus tracing technique (70-80ml of non-ionic CM injected with a rate of 5-6 ml /sec injected via dual-head Medrad stellant power injector pump together with (50ml) saline chaser bolus to washout contrast medium from right side of the heart). Image acquisition started when contrast threshold reaches 180 with ROI at descending aorta, from carina to 1cm below the diaphragm.

Post procedural evaluation of patient: The patient is kept under observation after the procedure for 15 minutes to assess the vital signs (pulse and blood pressure).

Image reconstruction and interpretation: Two radiologists evaluated and analyzed the cases in consensus, on an advanced Philips workstation using axial images (as source images), reconstructed images like Mmaximum Intensity Projection (MIP), MPR (curved and oblique), and volume rendering techniques.

STATISTICAL ANALYSIS

Data were collected, coded, entered and analyzed using Microsoft Excel software. Data was then imported into Statistical Package for the Social Sciences (SPSS version 23.0) software for analysis. Qualitative data were represented as numbers and percentages, and quantitative data were represented by mean ± SD. Differences between quantitative paired groups were tested by Student t-test and paired t-test for significance.

The P-value was set at <0.05 for significant results and <0.001 for a highly significant result.

RESULTS

Best phase of cardiac cycle for CVS assessment

Phase 45% was the best phase; most cardiac veins were best seen in (Table 1).

The Percentage of Presence of main cardiac veins and Thebesian Valve

CS is the most constant component of the cardiac venous system and was detected in all patients. Great Cardiac Vein (GCV), Anterior interventricular Vein (AIV) and Middle Cardiac Vein (MCV) were visualized in all patients. Posterior Vein of Left Ventricle (PVLV) was noted in 96.7% of patients. Left Marginal Vein (LMV) was visualized in 73.3% of patients. Small Cardiac Vein (SCV) was present in 13.3% of patients. Thebesian valve was observed in 73% of patients (Table 2).

CS diameter: The mean ostial CS anteroposterior diameter was 12.58 ± 2.44 (range, 9–21 mm) while the mean ostial CS superoinferior diameter was 17.2 ± 2.55 (range, 13.3–23.2 mm) (Table 3). The diameter of the CS ostium in the superoinferior direction was significantly larger than that in the anteroposterior direction. (t= 14.804, P <0.001) (Table 3).

Measurements of angles between CS and its main tributaries

In our study, the CS-MCV angle ranged from 53.8° to 88° (mean, 71.34° ± 8.09°). The CS-PVLV angle ranged from 90° to 120° (mean, 100.54° ± 3.93°) (Table 4).

Table (1): Percentage of coronary veins detection in systolic and diastolic phases.

Cardiac veins	Phase			
	Phase 45%		Phase 75%	
	No.	%	No.	%
Coronary sinus	26	86.67%	4	13.33%
Great cardiac vein	23	76.67%	7	23.33%
Middle cardiac vein	23	76.67%	7	23.33%
Anterior inter-ventricular vein	23	76.67%	7	23.33%
Posterior vein of the left ventricle	22	75.86%	7	24.14%
Left marginal vein	14	63.64%	8	36.36%
Small cardiac vein	2	50%	2	50%

Table 2: The Percentage of identification of main coronary veins and Thebesian Valve.

Cardiac veins	No of cases	Frequency of presence (%)
Coronary sinus	30	100
Great cardiac vein	30	100
Middle cardiac vein	30	100
Anterior inter-ventricular vein	30	100
Posterior vein of the left ventricle	29	96.7
Left marginal vein	22	73.7
Small cardiac vein	4	13.3
Thebesian Valve	22	73

Table 3: Coronary sinus diameter.

CS ostium	Mean ± SD (mm)	Range (mm)	T	P value
Anteroposterior diameter	12.58 ± 2.44	9 – 21	14.804	< 0.001
Superoinferior diameter	17.2 ± 2.55	13.3 – 23.2		

Table 4: Angle between CS and (MCV, PVLV).

	CS-MCV/°	CS-PVLV/°
Mean	71.343	100.547
Median	72	102
Std. Deviation	8.094	20.941
SEM	1.51	3.937
Minimum	53.8	90
Maximum	88	120

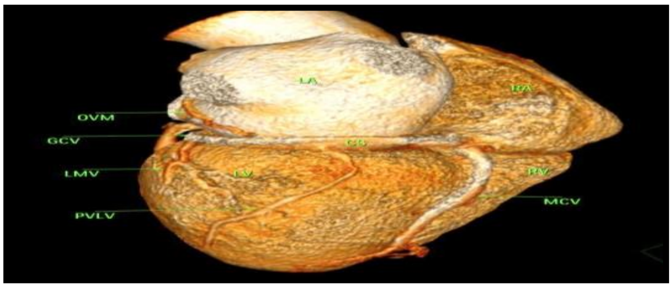

Figure (1): Three dimensions volume rendered image (posterolateral view) showing normal cardiac venous tributaries: Coronary Sinus (CS), Oblique Vein of left atrium (OVM), Great Cardiac Vein (GCV), Left Marginal Vein (LMV), Posterior Vein of Left Ventricle (PVLV) and Middle Cardiac Vein (MCV).

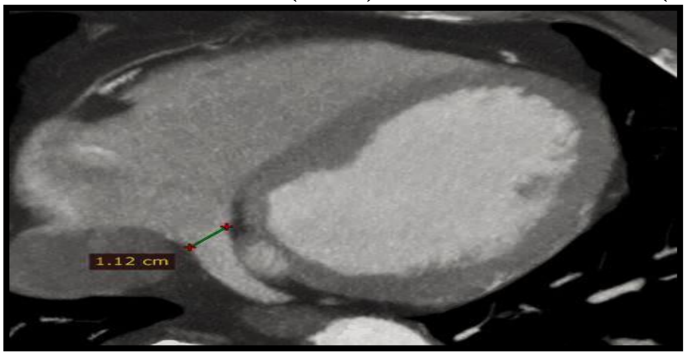

Figure (2): This figure shows Axial Maximum Intensity Projection image illustrates measurement of the CS diameter in antero-posterior direction at the coronary sinus ostium (CSO) (Green line). Also shows Thebesian valve which appears as thin hypodense leaf guards the CSO and represents the distal end of the CS (Yellow arrow)

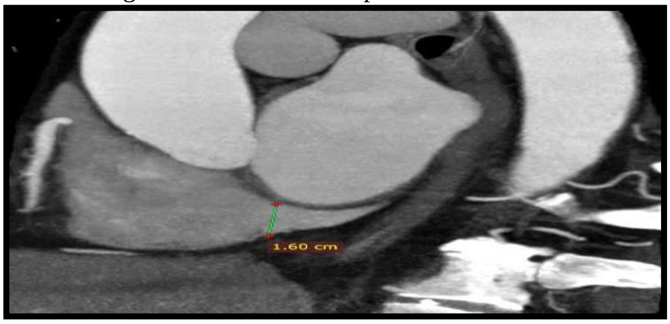

Figure (3): Coronal Multi-Planner Reformatted image shows measurement of the CS diameter supero-inferior direction at the coronary sinus ostium (CSO) (Green line).

DISCUSSION

The cardiac venous system is increasingly being used as a route of entry into the heart for numerous electrophysiological purposes, as radiofrequency catheter ablation (RFA), defibrillation, percutaneous mitral annuloplasty (PMA) and cardiac resynchronization therapy (CRT) for arrhythmias and heart failure treatment **[4, 8]**. In recent years, MDCT coronary angiography has become the preferred method to evaluate the coronary venous system. It also enables accurate noninvasive detection of normal anatomy of cardiac veins offering a road map before CRT and electrophysiologic procedures **[11].**

In the current study on thirty patients, there was no significant correlation between patients' age, sex, risk factors and their coronary veins diameters (p-value > 0.05); this agreed with **Genc et al. [12]** who reported that there was no significant difference between the diameters or visibilities of the veins in terms of age.

In our study, we found that systolic phase of cardiac cycle (45%) was the best phase in which most cardiac veins were best seen. Coronary sinus was best seen in phase 45% in 86.67% patients, GCV, MCV & AIV were best seen in phase 45% in 76.67% patients. PVLV, LMV and SCV were best seen in phase 45% in 75.86%, 63.64 and 50% patients, respectively, these results ties well with **Tada et al. [8]** who found that because the diameters of the coronary veins were usually greater in images acquired during systole than during diastole, the Systolic-Images (30%,40%, and 45% of the R wave-to-R wave interval) were preferable for identifying the origin and course of the tributary veins from the CS, and also **Shah et al. [13]** who reported that if multiphasic data are available, the systolic reconstruction phases

(35%–45%) are generally favored due to better coronary venous distention.

In Our study, we found that CS, GCV, AIV and MCV were visualized in all cases. The PVLV was visualized in 96.7% patients. LMV was visualized in 73.7% of patients. The SCV was visualized in 13.3% of patients. Similar findings were reached by the study of **Sun et al. [11]** who reported that CS, GCV, AIV and MCV were visualized in all cases. The PVLV was visualized in 77.5% of patients. LMV was visualized in 66.7% of patients. The SCV was visualized in 27.5% of patients. As well close to **Malago et al. [10]** who found that CS, GCV, AIV and MCV were visualized in all cases (100%). The PVLV was visualized in 82% of patients. LMV was visualized in 84% of patients. The SCV was visualized in 18.9% patients. By shedding light on thebesian valve, in our study it was observed as a small hypodense leaf at the coronary sinus ostium in 73% patients, this is in concordance with previous studies of **Malago et al. [10] and Genc et al. [12]** who found that the Thebesian valve was observed in 77% and 72.2% patients, respectively.

We also found that the diameter of the CS ostium in the superoinferior direction (mean 17.2 ± 2.55) was larger than that in the anteroposterior direction (mean 12.58 ± 2.44) with a high statistically significant difference (P <0.001). These results were consistent with **Jongbloed et al. [7]** who reported that the mean diameter of the ostium of the CS in the anteroposterior direction was 12.6 ± 3.6 mm and 15.5± 4.5 mm in the superoinferior direction. In the superoinferior direction, the diameter of the ostium was significantly larger (P <0.01) indicating an asymmetrical shape of the ostium, with the long axis in the superoinferior direction.By the end of statistical analysis of the angle of drainage between CS and the main tributaries: MCV and PVLV, our results verified that the CS-MCV angle was acute, its mean was (71.343°±8.094°), while CS-PVLV angle was obtuse and its mean was (100.547°±20.941°). These results agree with **Sun et al. [11]** who reported that the angle between CS and MCV was acute and its mean equals 71°±1.7° while the angle between CS and PVLV is obtuse and its mean measures 109°±18°.

There were some limitations to the study. First, this single-central study and involved a small sample size thus requires confirmation by involving larger multi-central studies and larger sample size. Second, use of a sub-optimal protocol for cardiac veins (retrospective evaluation in patients with suspected CAD).

CONCLUSIONS

In conclusion, MDCT coronary angiography is an excellent non-invasive modality in delineation of cardiac veins anatomy and allowing a preliminary assessment of the cardiac venous anatomy before catheterization and lead placement. We recommend using coronary CTA as a routine preliminary investigation before any coronary interventional procedure or cardiac resynchronization therapy.

CONFLICT OF INTEREST: None
FINANCIAL DISCLOSURE: None

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