Characterization of the cardiac venous system in heart failure patients using 256-slice CT

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In patients with congestive heart failure (HF), pacemaker leads for cardiac resynchronization therapy (CRT) are placed in one of the tributaries of the coronary sinus (CS) system, located in the lateral wall of the left ventricle [1]. In selected patients, CRT reduces symptoms and improves exercise capacity [2]. The cardiac resynchronization–heart failure trial also reported a significant reduction of morbidity and mortality compared to optimized medical treatment [3]. However, in 5% to 12% of patients in large clinical trials, the CRT procedure does not succeed [4], and these numbers may be higher in inexperienced centers. Failure of left ventricular lead placement has been attributed to the inability to insert catheters in the CS and the lack of suitable side branches [5]. Knowledge of characterization of the cardiac venous system may facilitate left ventricular lead positioning.

A previous study showed the feasibility of noninvasive visualization of the cardiac venous system in coronary artery disease (CAD) patients using 64-slice CT [6]. Our previous study showed contrast-enhanced whole-heart coronary MRA at 3.0T can depict the normal and variant cardiac venous anatomy in patients with suspected CAD and healthy volunteers [7,8]. Our recent study reported 256-slice CT provides superior noninvasive evaluation of the coronary venous system [9]. However, the efficacy of multislice CT for cardiac venous assessment specifically in patients with congestive HF has not been assessed in these previous studies. The aim of the present study was to evaluate the characterization of the cardiac venous system in HF patients

using 256-slice CT.

The anatomic characterization of the cardiac venous system was studied in 90 patients (48 men and 42 women; age 59 ± 13 years). The population was divided in 2 groups. Forty-five patients had HF, and the other forty-five patients did not have HF.

Imaging was performed with a retrospectively ECG-gated CT coronary angiogram using 256-slice CT (Brilliance iCT, Philips, Cleveland, Ohio, USA). The coronary CTA scan parameters were as follows: tube voltage, 100 kVp; effective tube current-time product, 700 mAs; pitch, 0.18; detector configuration, 128×0.625 mm; rotation time, 270 ms. The heart rate was controlled under 90 beats per minute by β -blocker prior to CTA. The contrast agent (Ultravist 370, Bayer Schering Pharma AG, Berlin, Germany) was given in 3 phases: 60 ml of contrast agent (average), then 15 ml of contrast agent and 15 ml of saline (50%/50%) and finally 30 ml of saline flush. Automatic bolus tracking (Bolus Pro, Philips Healthcare, Cleveland, OH, USA) was used by defining a region of interest in the ascending aorta at the level of aorto-pulmonary fenestration, with the scans initiated 6 s after the signal attenuation reached a predetermined threshold of 180 Hounsfield Units (HU).

The tributaries of the cardiac veins were identified on volume-rendered reconstructions. Thereafter, the course of the veins was evaluated in 3 orthogonal planes using multiplanar reformatting. The presence of the following cardiac veins was evaluated: CS, posterior interventricular vein (PIV),

posterior vein of the left ventricle (PVLV), left marginal vein (LMV), and anterior interventricular vein (AIV).

The ostium of the CS was defined as the site where the CS makes an angle with the right atrium in the crux cordis area. Multiplanar reformatting was used to determine the size of the ostium of the CS in anteroposterior and superoinferior direction and to measure the starting diameter of each identified tributary. The angle of the CS ostium was measured in the axial images. The length of the tributaries, the distance from the ostium to tributaries and the angle between the tributaries and CS or great cardiac vein were measured on volume-rendered reconstructions.

A statistical software program, SPSS 13.0 (SPSS Inc., Chicago, IL, USA), was used for statistical analysis. Continuous variables were expressed as mean $\pm$ standard deviation. Categorical variables were expressed as absolute number (percentage). Comparisons were performed using Student t test. Statistical tests were 2-tailed, and a p-value < 0.05 was considered to be significant.

The CS and the CS ostium were identified in all patients. The angle of the CS ostium in patients with HF was $69^{\circ} \pm 9^{\circ}$, compared with the angle of the CS ostium in patients without HF, which was $61^{\circ} \pm 8^{\circ}$ ($p < 0.05$). For patients with and without HF, the diameter of the CS ostium in the superoinferior direction was significantly larger as compared to the anteroposterior direction. There was no significant difference in the diameter of the CS ostium in patients with

as compared with those without HF. The ostial diameters of the tributaries of the CS system were significantly larger in patients with as compared with those without HF. There was no significant difference in the length of the tributaries, the distance from the ostium to tributaries and the angle between the tributaries and CS or great cardiac vein in patients with as compared with those without HF. The quantitative measurements are presented in Table 1.

A unique aspect of this study is that it compared the characterization of the cardiac venous system among patients with and without HF. The major findings in the current study are 2-fold. First, the angle of the CS ostium in patients with HF is less acute than the angle of the CS ostium in patients without HF. Second, the ostial diameters of the tributaries of the CS system are significantly larger in patients with as compared with those without HF.

Compared with the older generation multislice CT, the 256-slice CT with the reduction of scanning time, breath-holding duration, motion artifacts, contrast medium and radiation dose can provide superior noninvasive visualization of the cardiac venous anatomy. Our study is the first to evaluate the characterization of the cardiac venous system in HF patients using 256-slice CT.

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Table 1

Quantitative measurement of the cardiac venous system using 256-slice CT.

	No HF	HF	p Value
Diameter (cm)			
CS ostium, anteroposterior	0.7 ± 0.2	0.8 ± 0.2	NS
CS ostium, superoinferior	$1.0 \pm 0.3^*$	$1.1 \pm 0.3^*$	NS
PIV	0.4 ± 0.1	0.6 ± 0.1	< 0.05
PVLV	0.3 ± 0.1	0.5 ± 0.1	< 0.05
LMV	0.2 ± 0.1	0.5 ± 0.1	< 0.05
AIV	0.3 ± 0.1	0.5 ± 0.1	< 0.05
Angle of the CS ostium	$61^\circ \pm 8^\circ$	$69^\circ \pm 9^\circ$	< 0.05
Length (cm)			
PIV	3.2 ± 1.9	3.5 ± 2.2	NS
PVLV	2.7 ± 2.6	2.5 ± 1.9	NS
LMV	1.9 ± 1.8	2.0 ± 2.0	NS
AIV	4.6 ± 1.7	4.0 ± 1.6	NS
Distance from the ostium of			
CS (cm)			
PIV	0.5 ± 0.5	0.4 ± 0.5	NS
PVLV	3.1 ± 1.1	3.3 ± 1.4	NS
LMV	7.0 ± 1.2	6.5 ± 1.1	NS

AIV	9.8 ± 1.6	10.1 ± 1.9	NS
Angle between the identified veins and CS or great cardiac vein			
PIV	83° ± 20°	85° ± 27°	NS
PVLV	107° ± 23°	106° ± 21°	NS
LMV	121° ± 29°	124° ± 31°	NS
AIV	135° ± 19°	131° ± 17°	NS

Data are means ± standard deviations. *p < 0.05 as compared with the diameter in the anteroposterior direction.

HF = heart failure; CS = coronary sinus; PIV = posterior interventricular vein; PVLV = posterior vein of the left ventricle; LMV = left marginal vein; AIV = anterior interventricular vein.