Non invasive visualization of cardiac venous system anatomy using 64-slice computed tomography

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Purpose

The study of the venous drainage of the heart has been overshadowed by the study of the coronary arterial system. Recent experience has demonstrated the potential value of the cardiac venous system (CVS) in several clinical interventions, not the least cardiac resynchronization therapy (CRT).

In patients with heart failure, NYHA Class III, left bundle branch block and wide QRS pacemaker leads for CRT are placed in the CVS. Coronary veins close to the left ventricle are used for the implantation of an electrode for stimulation of left ventricular myocardium (LV-LEAD). Non invasive preview of coronary venous anatomy may facilitate the implantation of the LV lead.

Before the introduction of multislice CT (MSCT), retrograde venous angiography represented the conventional technique for studying the coronary veins. The limitations of the technique in terms of invasiveness, examination duration, inability to visualize both the vessels and cardiac wall at the same time, not always optimal depiction of cardiac veins, the need for large amount of contrast agent and impossibility to selectively catheterise the CS and its tributaries in a significant percentage of cases targeted the efforts of scientific research toward the realization of a non invasive diagnostic tool for the evaluation of the cardiac venous system.

Technological evolution in the field of MSCT has provided scanners with progressive improvement in spatial and temporal resolution that makes them more and more capable of analyzing moving organs with high quality anatomic detail.

MSCT has been taking on an increasingly important role as non invasive modality in the evaluation of cardiac veins. The purpose of the present study is to evaluate the different components of cardiac venous system anatomy using 64-slice multidetector computed tomography (64-MSCT).
Methods and Materials

We retrospectively reviewed CT coronary artery angiography of 300 patients and evaluate the different anatomic components and possible variants of the cardiac venous system we were able to identify in the same scans. Patients with heart rate > 70 bpm received a 100 mg oral dose of metoprolol 60-90 min before the examination.

Imaging study was performed with 64-detector raw Light Speed VCT scan (GE Medical Systems, Milwaukee, USA) using 120 ml of contrast material (iomeprol, Iomeron 400 mg/l/ml, Bracco, Milan, Italy) at an injection rate of 5 ml/min followed by a 50 ml bolus of saline solution at the same flow rate using an 18-gauge needle cannula inserted into an antecubital vein of the arm and a dual-head automatic injector (Stellant D, Medrad, PA, USA).

The beginning of the scan was synchronized with the arrival of contrast agent by using the Smart Prep technique, with a region of interest (ROI) positioned in the ascending aorta and a threshold set at a density value of 100 HU greater than baseline value. No particular venous protocol was used.

Scanning was performed using 64 slices with a collimated thickness of 0.6 mm; multiplanar and volume rendered reconstructions of the venous system and cardiac chambers were then obtained and evaluated both by the radiologist and cardiologist.

In the current report we accepted and used the terminology described by von Lüdinghausen (2003).
Results

We described the different anatomic components of the cardiac venous system: coronary sinus, the great cardiac vein, the anterior interventricular vein, the posterior vein (s) of the left ventricle, the left marginal vein, the oblique vein of the left atrium, the posterior interventricular vein. We describe the anatomy of the Thebesian Valve (ostial valve of the CS) and the presence of different variations in cardiac venous anatomy: anomalies in the number of coronary veins (absence, supernumerary), persistent left superior vena cava draining in the CS, CS stenosis and complex venous anomalies.

THE GREATER CARDIAC VENOUS SYSTEM

The greater cardiac venous system drains most of the myocardium and these vessels are routinely used in clinical practice for placement of left ventricular leads and ablation therapies.

CORONARY SINUS (CS)

It is a large and a short vein usually running in the left half of the posterior atrioventricular groove in the diaphragmatic surface of the heart. The mean length is about 3 cm and diameter about 12 mm (range 6-16 mm); it shows an oval shape with the supero-inferior diameter exceeding the antero-posterior one. It begins at the termination of great cardiac vein (GCV) and terminates in the right atrium. The ostium of the CS is guarded by a rudimentary valve, the Thebesian valve (TV).

Tributaries of the CS are the GCV, the posterior interventricular vein (PIV), the posterior vein of the left ventricle (PVLV), the left marginal vein (LMV), the oblique vein of the left atrium (OVLA) and the small cardiac vein (SCV).

The TV is found in at least 80% of adult hearts and it is widely variable in terms of shape, size and thickness. The mouth can be opened or completely occluded. The valve can be almost absent, imperforate or widely fenestrated. The shape can be circular, semilunar (the most frequent), crescentic or band-like.

THE GREAT CARDIAC VEIN (GCV)

The GCV it is the largest of the CS tributaries. It arises from the cardiac apex like anterior interventricular vein (AIV) and runs in the anterior interventricular groove and left atrioventricular groove (GCV) to open into the CS. The Valve of Vieussens (VV)is at the
junction of GCV with OVLA; some take the site of the VV as marking the end of the GCV and the beginning of the CS.

Diameter of AIV: 2.7 mm (range 0.9-4.4 mm), Diameter of GCV: 5.2 mm (range 3-7 mm).
Diagonal branches of the AIV with good diameter can be use to place the LV-LEAD.

OBLIQUE VEIN OF THE LEFT ATRIUM (OVLA, Marshall vein)

This vein is present in about 84% of the cases in different series. First described by Marshall as remnant of left superior vena cava. It traverses and descends the left lateral and posterior wall of the left atrium and enters the CS at its left end, i.e., 1-12 mm distal to the terminal valve (VV) of GCV. Length: 2-3 cm; Mean diameter: 1 mm.

THE POSTERIOR INTERVENTRICULAR VEIN (PIV)

The PIV is a constant structure. It originates in the diaphragmatic surface of the heart near the ventricular apex, runs in the posterior interventricular groove and drains into the CS adjacent to its atrial ostium. Rarely PIV drains separately in the right atrium.
Mean diameter: 3.6 mm (range 2.1-5.3 mm)

THE POSTERIOR VEIN (S) OF THE LEFT VENTRICLE (PVLV)

The PVLV drains the lateral and diaphragmatic walls of the left ventricle.
Most commonly, the vein is present like a single large vessel (63% of cases), albeit that several smaller veins can serve to drain the same myocardial areas.
In one twentieth of the overall population this vessel may be absent.
This vein can be used like target vein where to place the LV-LEAD.
Mean diameter: 2.4 mm (range: 1-5.5 mm)

THE SMALL CARDIAC VEIN (SCV)

Present in 37-54% of the different series. SCV is a minute tributary of the CS; it runs parallel to the right coronary artery in the right coronary sulcus and empties into the PIV or directly into the CS; it can show separate drainage in the right atrium.
Mean Diameter: 1 mm

THE LEFT MARGINAL VEIN (LMV)

LMV also named the obtuse marginal vein. LMV is present in 73-88% of different series. The vein courses over the left oblique marginal surface of the heart, draining much of the left ventricular myocardium running parallel to the marginal branch of the left coronary artery.

In 79% of the cases it empties in the GCV, in 21% it drains directly into the CS.

Average diameter: 2.2 mm (range 1-3 mm). Like other coronary veins LMV is enlarged in patients with cardiac failure. The LMV with appropriate characteristics represents the ideal target vein to place the LV-LEAD for CRT.
Images for this section:

Fig. 1: MSCT (3D VR reconstruction): coronary sinus (CS), great cardiac vein (GCV), posterior vein left ventricle (PVLV), posterior interventricular vein (PIV), small cardiac vein (SCV)

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**Fig. 2:** MSCT (3D VR reconstruction): coronary sinus (CS), great cardiac vein (GCV), posterior vein left ventricle (PVLV), posterior interventricular vein (PIV)

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**Fig. 3:** MSCT (3D VR reconstruction): posterior interventricular vein (PIV), posterior vein left ventricle (PVLV), oblique vein left atrium (OVLA)

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Fig. 4: MSCT (3D VR reconstruction): left marginal vein (LMV), obtuse marginal branch (OM) of the circumflex artery

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**Fig. 5:** MSCT (3D VR reconstruction): great cardiac vein (GCV), posterior vein left ventricle (PVLV), anterior interventricular vein (AIV)

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Fig. 6: MSCT (3D VR reconstruction): great cardiac vein (GCV), anterior interventricular vein (AIV)

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Fig. 7: A: Axial image. Thebesian valve (TV) coronary sinus (CS)

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**Fig. 8:** Thebesian valve (TV) covering almost completely the ostium of the coronary sinus (CS OS)

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Fig. 9: Virtual angioscopy reconstruction: Thebesian valve (TV) covering almost completely the ostium of the coronary sinus (CS OS)

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Fig. 10: MSCT (3D VR reconstruction): Anomaly of position: "high riding" CS: CS does not run in the atroventricular groove

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Fig. 11: MSCT (3D VR reconstruction): Anomaly of size: Stenosis of the coronary sinus (CS stenosis)

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Fig. 12: MSCT (3D VR reconstruction): Anomaly of number and position: agenesis of the posterior vein of the left ventricle and "high riding" CS

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Fig. 13: MSCT (3D VR reconstruction) Anomaly of number: two little posterior vein of the left ventricle and "high riding" CS.

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**Fig. 14:** Anomaly of number: multiple little posterior veins of the left ventricle and "bulbous" dilatation of the distal tract of the posterior interventricular vein (ectasia)

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**Fig. 15:** Congenital malformation: persistent left superior vena cava

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Fig. 16: Congenital malformation: persistent left superior vena cava draining into a dilated coronary sinus: MSCT (oblique sagittal reconstruction): persistent left superior vena cava (PLSVC), coronary sinus (CS)

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Fig. 17: Congenital malformation: persistent left superior vena cava draining into a dilated coronary sinus (CS) MSCT(3D VR reconstruction): persistent left superior vena cava (PLSVC), coronary sinus (CS)

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Conclusion

64-MSCT provides good visualization of the coronary veins. There is considerable variation in cardiac venous anatomy.
References


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