Non invasive visualization of cardiac venous system using 64-slice computed tomography before cardiac resynchronization therapy: a single center experience

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Purpose

Left ventricular pacing in cardiac resynchronization therapy (CRT) is achieved by positioning the left ventricular lead (LV LEAD) in one of the tributaries of the coronary sinus (CS). Despite the rapid evolution of CRT implantation techniques the transvenous approach is not feasible in a percentage between 5% and 8% of the potential candidates; besides in 30% of the cases it is not possible to stimulate the delayed area of the left ventricle.

Interindividual anatomic variants of the cardiac venous system, congenital anomalies, previous cardiac surgery and previous myocardial necrosis may be responsible for this high rate of non successful results.

In recent series MSCT proved able to visualize the cardiac venous system with high accuracy.

Non invasive preview of coronary venous anatomy (presence of the target vein, its diameter, the take off angle from CS body, presence of potential anatomic obstacles for the LV-LEAD implantation like prominent Thebesian valve, CS stenosis, detection of phrenic nerve and its relation with the target vein) may facilitate the implantation of the LV lead.

The purpose of this study is to assess the role of 64-slice computed tomography (64-MSCT) for the preoperative planning before CRT.

Methods and Materials

14 consecutive patients (70±6 years, 11/14 males) with heart failure NYHA Class III, left bundle branch block with wide QRS (>130 ms) EF of 0.30, no clinical history of acute coronary syndrome, referred to our center for CRT device implantation underwent 64-MSCT of the cardiac venous system before the procedure in order to identify possible target veins (TVS) and their anatomy. 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 mgl/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 region of interest (ROI) of the SmartPrep was placed in the CS in order to obtain adequate enhancement of the venous system. 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.

We considered the: the presence of TVS: left marginal vein (LMV), posterior vein of the left ventricle (PVLV)) and anterolateral veins, their number, caliber, path and the take-off angle of TVS from CS body; according to these data an opinion of feasibility of the CRT procedure was then expressed.

Moreover we evaluated the occurrence of potential obstacles for CRT procedure like the presence of a prominent Thebesian Valve (TV) (valve leaflets covering more than 40% of the CS ostium), CS stenosis (>70%) and the relation of left phrenic nerve (LPN) to TVS able to determine inappropriate stimulation of the nerve itself when pacing left ventricular wall. Patient then underwent CRT procedure via transvenous approach.

**Results**

In Table A we reported the clinical data of the study population.

In 45% of patients myocardial ischemia was the etiology of heart failure; 2 patients had previous coronary artery bypass surgery (CABG), 2 patients had previous pacemaker implantation with anti bradicardic indication.

**Tab. A. Study Population: clinical data**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>70±6</th>
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<tbody>
<tr>
<td>Males (%)</td>
<td>11/14</td>
</tr>
<tr>
<td>Previous MI</td>
<td>3/14</td>
</tr>
<tr>
<td>EF (%)</td>
<td>30± 5</td>
</tr>
<tr>
<td>CAD</td>
<td>6/14</td>
</tr>
<tr>
<td>Previous CABG</td>
<td>2/14</td>
</tr>
<tr>
<td>Previous PTCA</td>
<td>3/14</td>
</tr>
</tbody>
</table>
MSCT EVALUATION OF CARDIAC VENOUS ANATOMY

In all cases it was possible to evaluate cardiac venous anatomy in detail.

LMV was identified in 72% of cases; PVLV in 61%; both in 5 patients, no TVS in 1 patient. 70% of LMV were considered good for cannulation (diameter>3 mm, take-off angle≠90, non tortuous path).

Prominent TV was identified in 3 patients (CS ostial stenosis > 40%); during CRT intervention the CS was successfully cannulated with a standard procedure. The electrophysiologist was prepared to use dedicated devices (Steerable catheter) for the cannulation of the CS via femoral vein.

A significant stenosis of the CS was present in one patient with previous CABG.

Phrenic nerve was identified in 70% of cases and venous branches in close proximity were excluded from cannulation in order to avoid inappropriate stimulation of the nerve itself (2 TVS close to LPN were excluded).

A complex venous anomaly was identified in one case: atresia of the CS with two independent venous drainage systems:

1) Posterior: posterior interventricular vein and a remnant CS draining into the right atrium

2) Anterior: anterior vein draining in a kind of "venous lake" that via a subtle anonymous vein drains directly into subclavian vein.

To our knowledge CT features of this anomaly were never described before.

Unfortunately image quality was disturbed by the occurrence of a paroxystic crisis of atrial fibrillation.

MSCT data about venous anatomy are summarized in Table B.

Table B. Venous Anatomy
<table>
<thead>
<tr>
<th>Veins</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVLV</td>
<td>8</td>
</tr>
<tr>
<td>LMV</td>
<td>6</td>
</tr>
<tr>
<td>PVLV+LMV</td>
<td>5</td>
</tr>
<tr>
<td>No PVLV/LMV</td>
<td>1</td>
</tr>
<tr>
<td>CS Stenosis</td>
<td>1</td>
</tr>
<tr>
<td>Prominent Thebesian Valve</td>
<td>3</td>
</tr>
<tr>
<td>Congenital venous anomalies</td>
<td>1</td>
</tr>
<tr>
<td>Visualization of phrenic nerve</td>
<td>4</td>
</tr>
</tbody>
</table>

(PVLV: posterior vein left ventricle, LMV: left marginal vein, CS: coronary sinus).

RESULTS OF THE MSCT GUIDED IMPLANTS

Veins considered good for the procedure on the bases of CT findings were successfully incannulated. Retrograde venous angiography was never performed and time for CRT was significantly reduced. The patient with no TVS underwent surgical positioning of the LV-LEAD.

CT finding proved useful for surgeon during epicardic lead positioning; MSCT allowed the identification of circumflex artery position and its relationship with left appendage in order to implant the LV-LEAD sufficiently far from circumflex artery.

In one case MSCT identified a complex and rare anomaly of the venous system; the knowledge of this complex anatomy before the procedure guided the electrophysiologist in the difficult positioning of the LV-LEAD in the anterior interventricular vein via left sublavian vein and small persistent left superior vena cava.

Images for this section:
**Fig. 1:** Posterior vein of the left ventricle (PVLV) with good diameter (>4 mm) and take-off angle >90° considered good for cannulation
Fig. 2: LMV with good diameter (>3 mm) and take-off angle of 90° considered sufficiently good for cannulation (LMVV: left marginal veins)
Fig. 3: LMV with good diameter but with take-off angle < 90° considered difficult for the procedure of cannulation. MO: obtuse marginal arterial branch
Fig. 4: LMV with acute take-off angle (}
**Fig. 5:** Absence of target veins (PVLV, LMV) for CRT.
**Fig. 6:** Prominent Thebesian Valve. TV: Thebesian Valve, OS: ostium of the coronary sinus
Fig. 7: Complex venous anomaly: atresia of the CS with two independent venous drainage systems: 1) Posterior: posterior interventricular vein (PIV) and a remnant CS draining into the right atrium 2) Anterior: anterior vein draining (ALV) in a kind of "venous lake" that via a subtle anonymous vein (PLSCV) drains directly into subclavian vein.
Fig. 8: Complex venous anomaly: atresia of the CS with two independent venous drainage systems Scheme of the anomaly. CRT was possible by placing the LV-LEAD in the ALV via left subclavian vein and PLSVC.
**Fig. 9:** Complex venous anomaly: atresia of the CS with two independent venous drainage systems Post intervention CXR. LV-LEAD, RV-LEAD are demonstrated.
**Fig. 10:** Left phrenic nerve (LPN) crosses the distal portion of a large posterior vein of the left ventricle (PVLV); during CRT we positioned the LV-LEAD in a more proximal branch of the PVLV (*asterisk) far from the LPN in order to avoid inadvertent stimulation of the nerve itself and unwanted diaphragmatic pacing.
Conclusion

Non invasive evaluation of cardiac venous anatomy for the preoperative planning in CRT proved useful in the selection of potential candidates for the transvenous approach, in the selection of catheters for venous cannulation and of the best vein to use.

Time of the procedure was reduced. Exposition dose was limited and retrograde venous angiography avoided

References


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