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Review

Value of multi-detector computed tomography in delineation of the normal cardiac conduction system and related anatomic structures

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ABSTRACT

The cardiac conduction system is responsible for rhythmic myocardial stimulation for physiologic contraction of the heart.
Aim of the work: To assess the value of MDCT in outlining anatomic landmarks and variants of conductive system, therefore provides crucial information used in clinical practice.
Patients and methods: Thirty adult patients (18 males, 12 females) (mean age: 51.5 years) underwent elective retrospective ECG gated cardiac angiography using 128 MDCT.
Results: MDCT enables accurate delineation of conduction system components such as SANa, AVNa, CT, BB, CTI, Koch triangle, LAI and PVs.
Conclusion: MDCT has a fundamental role in demarcating potential arrhythmogenic structures before ablation procedures.

Contents

Abbreviations: AF, atrial fibrillation; AVN, atrioventricular node; AVNa, atrioventricular nodal artery; BB, Bachmann's bundle; CS, coronary sinus; CT, crista terminalis; CTI, cavotricuspid isthmus; LAA, left atrial appendage; LCx, left circumflex artery; LIPV, left inferior pulmonary vein; MDCT, multi detector computed tomography; RCA, right coronary artery; RFCA, radio frequency catheter ablation; RIPV, right inferior pulmonary vein; RMPV, right middle pulmonary vein; RSPV, right superior pulmonary vein; SAN, sinoatrial node; SANa, sinoatrial nodal artery; SI, septal isthmus; STV, septal leaflet of tricuspid valve; VR, volume rendered; LAI, left atrial isthmus.

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1. Introduction

The conduction system is a population of myocytes that is responsible for generation of the cardiac electrical impulse and their conduction from the atrial to the ventricular chambers. The function of the cardiac conduction system is to ensure rhythmic myocardial stimulation thus leading to physiological contraction of the heart. Multiple anatomic and electrophysiological studies have provided strong background on the cardiac conduction system and its electrical connection structures [1–3].

Owing to the recent technologic advances in Multi detector CT (MDCT), it is emerging as a successful tool for noninvasive imaging of the cardiac anatomy with high resolution. It allows us to perform a virtual dissection of the cardiovascular system. Furthermore, MDCT has a fundamental role in anatomically delineating and outlining the cardiac sites related to the conduction system thus providing the electrophysiologist with an anatomic road map to facilitate the pacing and ablation procedures [1,2,4].

The cardiac conduction system is composed of the sinoatrial node (SAN), the atrioventricular node (AVN), the HIS bundle, the right and left bundle branches, the fascicles and the Purkinje fibers [5,6]. In addition to multiple related anatomic landmarks and variants, the right SAN artery, right atrial cavotricuspid isthmus, Koch triangle, AVN artery, interatrial muscle bundles, and pulmonary veins are included. The atrial components, the sub epicardial SAN and the sub-endocardial AVN are in contact with the atrial myocardium [5,7].

The rapid development of interventional procedures for the treatment of arrhythmias such as radiofrequency catheter ablation technique to precisely destruct minute arrhythmogenic tissues, has returned the interest in cardiac anatomy. Since anatomic variation of the cardiac conduction system landmarks and associated structures is common, it is necessary to be aware of these normal variants, especially prior to interventional procedures [8].

The purpose of our study was to assess the value of MDCT in outlining the anatomic landmarks and variants of the conductive system and therefore provide crucial information used in clinical practice.

2. Patients and methods

2.1. Study design and population

This study was prospectively conducted during the period from June 2014 to April 2016 at diagnostic radiology and cardiology departments, and included 30 cases (18 males and 12 females), ranging in age between 35 and 65 years old, with a mean age of 51.5 years. Patients were either self-referred or referred by a physician to our institute for elective multidetector CT coronary angiography.

We included adult patients of both sex with normal heart rate, suspected to have coronary artery disease.

The exclusion criteria were as follows: arrhythmias or irregular heart rate, inability to comply with the protocol requirements (renal insufficiency: creatinine level $\geqslant$1.6 mg/dl, inability to sustain a breath hold for 10–12 s, pregnant or lactating females), calcium score exceeding maximum score and a known case of thyroid dysfunction. Four patients were further excluded due to poor image quality from motion or respiratory artifact.

All patients were subjected to contrast-enhanced retrospective ECG gated CT coronary angiography using 128 MSCT Philips ingenuity machine.

3. Technique of cardiac imaging

3.1. Patient preparation

All patients were instructed to fast for 4–6 h prior to the examination with no discontinuity of their medications. No atropine or caffeine for 12 h before the study. Reassurance of the patients was done and all steps of the study were explained in detail to each patient.

To evaluate patients ability of breath-withholding for relatively long time, they were required to perform a deep inspiration and to continue to hold their breath for 12 s without pushing (Valsalva maneuver). During this trial, the patient was observed for compliance and the electrocardiogram for significant changes.

Beta blockers were administrated if resting heart rate before the scan is more than 65 bpm. 100–200 mg metoprolol was administrated orally 60 min before scanning (unless contraindicated). Ideally the heart rate variation should be within 5 bpm during the scan.

3.2. Scan preparation

- ECG leads were fixed at the mid of the right and left clavicles. The third one is fixed at the left costal margin after skin preparation of the patient to ensure good skin contact and avoid scar areas. Turn on the ECG machine, and ensure good connection to the gantry and leads.
- Contrast material:

A bolus of 100 ml of non-ionic contrast of nonionic contrast media, 350–370 mg of iodine per milliliter (Ultravist

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