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Review article – *Special issue: Imaging in Coronary Artery Disease*

Coronary CT angiography

Petr Kuchynka [a,b,*], *Lukáš Lambert* [c], *Vladimír Černý* [c], *Josef Marek* [a], *David Ambrož* [a], *Barbara Anna Danek* [a], *Aleš Linhart* [a]

[a] *2nd Department of Medicine – Department of Cardiovascular Medicine, First Faculty of Medicine, Charles University in Prague and General University Hospital in Prague, Czech Republic*
[b] *International Clinical Research Center, St. Anne's University Hospital in Brno, Czech Republic*
[c] *Department of Radiology, First Faculty of Medicine, Charles University in Prague and General University Hospital in Prague, Czech Republic*

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ABSTRACT

Coronary CT angiography (coronary CTA) represents an increasingly applied noninvasive method for coronary artery imaging. Due to technical development and improved spatial and temporal resolution of CT, high diagnostic value of coronary CTA is reported when compared to conventional selective angiography. The aim of this review is to present an overview of the clinical applications of coronary CTA. Important factors in patient selection and preparation are also briefly discussed.

Contents

* *Corresponding author at*: 2nd Department of Medicine – Department of Cardiovascular Medicine, General University Hospital in Prague, First Faculty of Medicine, Charles University in Prague, U Nemocnice 2, 128 08 Prague 2, Czech Republic. Tel.: +420 2 24962634; fax: +420 2 24912154.
E-mail address: petr.kuchynka@vfn.cz (P. Kuchynka).

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Introduction

Coronary artery disease (CAD) is the leading cause of morbidity and mortality in developed countries [1]. Invasive selective coronary angiography was the only method to image coronary arteries for a long time and is still the gold standard [2]. However, technology allowing nonivasive imaging by coronary CT angiography (coronary CTA) has progressed remarkably during the last three decades. Harrel and his research group laid the groundwork for cardiac CT already in 1976 and 1979 [3]. The basic principles of their reconstruction technique and particularly their method of obtaining a short snapshot of the heart are still applied today in what is now known as multisegment reconstruction [3]. It took more than two decades of research after Harrel's initial experiment to develop CT scanners suitable for routine cardiac imaging. The introduction of 16-slice CT in 2003 and 64-slice CT in 2004 marked the arrival of technology with sufficient spatial and temporal resolution for assessment of coronary arteries [4]. Today, only ≥64-slice CT is considered to be appropriate for coronary artery imaging.

Basic aspects of image acquisition

Coronary CTA has some specific technical aspects which need to be briefly addressed. CT imaging of the heart requires minimization of cardiac motion artifacts. For this reason, coronary CTA scanning is performed with simultaneous ECG registration. Two basic methods are recognized: prospective triggering and retrospective gating. Prospective ECG triggering is a method in which the data are acquired at a pre-specified phase of the cardiac cycle. For coronary CTA, the phase with minimal heart motion and therefore minimal coronary artery motion (usually in mid-diastole or in end-systole in patients with an accelerated heart rate) is selected. In retrospective ECG gating, data are acquired throughout the entire cardiac cycle, and only the data obtained during the cardiac phase with the least motion artifacts are used for image reconstruction. The protocol for cardiac CT is highly dependent on the technology delivered by each vendor. Some vendors attempt to decrease the radiation dose by prospective triggering and fast rotation times, while others build their protocols mainly on helical scanning and ECG pulsing, where full dose images are acquired only during a pre-selected phase. Prospective ECG triggering is being performed more frequently in recent years because of its relatively low radiation dose (2–6 mSv) in comparison with the retrospective gating or pulsing methods (6–20 mSv). However, the most important disadvantage of prospective triggering lies in the fact that images can be reconstructed only for a pre-selected phase of the cardiac cycle, and functional assessment of the heart (e.g. assessment of left ventricular ejection fraction) is thus not feasible. All coronary CTAs are contrast examinations. Image quality depends on the contrast-to-noise ratio, and therefore high concentration iodine (e.g. 350 mg/ml or 400 mg/ml) contrast agents are preferred. Contrast volume ranges from 50 to 100 ml. The required injection rate is typically between 4 and 7 ml/s and so adequate intravascular access (20 gauge or 18 gauge intravenous cannula placed typically in the right antecubital vein is usually used) is needed. Optimal images require high intra-arterial opacification of more than 250 Hounsfield units (HU). Vascular enhancement should be maintained for the duration of data acquisition; therefore accurate timing of the scan is necessary. For this purpose, either the bolus tracking or the test bolus technique can be used. The bolus tracking technique is based on automatic scan triggering. In this strategy, the region of interest (left atrium, ascending or descending aorta) is selected and is sampled every 1–2 s after the initiation of contrast agent administration. When the density in the selected region exceeds target density value (e.g. 100 HU), scanning is started. In the test bolus strategy, a small test bolus is administered, and sampling is performed at the region of interest every 1–2 s, allowing measurement of the time to contrast arrival. This time is then used to trigger the scan acquisition once the full contrast dose has been administered.

Patient preparation

The following set of recommendations is usually given to the patient undergoing coronary CTA [5]: (1) no food intake for 4 h before the examination; (2) drinking of water or clear fluids up until time of the examination is not restricted and is even encouraged, mainly to improve hydration of the patient in order to prevent renal impairment caused by contrast agent administration and also for the ease of establishing venous access; (3) caffeine products should be restricted 12 h before examination, as they might hinder efforts to reduce the heart rate before scanning; (4) regular blood pressure medication, particularly heart rate lowering drugs, should not be discontinued prior examination; (5) pre-medication for contrast allergy as prescribed by the referring physician; (6) metformin discontinuation for 48 h after examination is usually advised although this recommendation seems to be nowadays rather