Multi-Detector Computed Tomography versus Invasive Coronary Angiography for Guiding Percutaneous Coronary Intervention in Chronic Total Occlusion

Thesis

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بسم الله الرحمن الرحيم

قالوا

سبحانك لا علم لنا إلا ما علمتنا إنك أنت العليم الحكيم

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List of Abbreviations

Abb.	Full term
BMI	*Body mass index*
CAG	*Coronary angiography*
CART	*Controlled Antegrade and Retrograde subintimal Tracking*
CC	*Collateral connection*
CTCA	*Computed tomography coronary angiography*
CTO	*Chronic Total Occlusion*
DESs	*Drug-eluting stents*
ICA	*Invasive coronary angiography*
IVUS	*Intravascular ultrasound*
LV	*Left ventricular*
MACE	*Major Adverse Cardiac Events*
MDCT	*Multi detector computed tomography*
MIP	*Maximum intensity projection*
MPR	*Multi-planar reformation*
MPRs	*Multiplanar reconstructions*
MRCD	*Maximum Recommended Contrast Dose*
MSCT	*Multi-slice CT*
OTW	*Over The Wire*
PCI	*Percutaneous coronary intervention*
RCA	*Right coronary artery*
STAR	*Subintimal Tracking and Re-entry*
TIMI	*Thrombolysis in myocardial infarction*
VR	*Volume-rendered*

INTRODUCTION

Coronary total occlusion (CTO) has been recognized in nearly 15% of patients undergoing invasive coronary angiography (ICA). CTO represents around 10% of lesions treated by percutaneous coronary intervention ***(Park, 2012).***

Occlusion of native coronary artery, when estimated from the clinical events to be at least more than three months, with no luminal continuity and TIMI (Thrombolysis in myocardial Infarction) 0 or 1 antegrade flow on angiography, has been defined as chronic total occlusion (CTO). Most importantly there should be clinical and / or angiographic evidence of the duration of occlusion to be more than three months old ***(Sianos et al., 2012).***

Prior to the availability and widespread use of CT coronary angiography, invasive coronary angiography (CAG) had been the only tool to assess morphology of coronary lesion. However, conventional invasive coronary angiography has essentially been a ‘lumenogram’, and therefore CTO lesion appears to halt the antegrade flow of contrast at the point of occlusion ***(Hoye et al., 2005)*****.** The distal vessel is visualized by contrast filling through the collaterals (bridging or contralateral source) when present and the CTO segment appears to be a missing segments between the two ends. Conventional invasive angiogram fails to define the condition of vessel wall, the exact path or length or angulation through the occlusion, the presence of side branches, the composition of CTO and the ‘proximal’ and ‘distal’ caps at either end ***(Puma et al., 1995).***

The clinical and anatomical predictors of unsuccessful PCI of CTO includes – more than 3 months duration of occlusion, presence of moderate and severe calcification, more than 15 mm length of occluded segment, blunt CTO stump, presence of bridging collateral, tortuosity in vessel proximal to and involving CTO, and presence of side branch at the level of occlusion. PCI of CTO solely based on conventional invasive angiogram, which cannot define these morphological features, is the major reason for failure in this subset ***(Noguchi et al., 2000).***

Over the years, rapid advancement has occured in CT imaging. Introduction of multi-slice CT (MSCT) scanners with 64 or more slices in one gantry rotation has improved spatial and temporal resolution and has been increasingly used for non-invasive CT coronary angiography (CTCA). Faster rotation times and decrease in slice thickness have reduced partial volume effects and motion artifacts, therefore improving the visualization of coronaries and morphological details of the occlusive lesions. In the recent studies, the quantitative and qualitative diagnostic values of CTCA have been found to be comparable to invasive CAG with limitations ***(Raff et al., 2005).***

MDCT exhibited good accuracy in delineating morphological features of coronary plaque, fairly classifying and quantifying plaque volumes and calcification, in proximal coronary tree in particular ***(Leber et al., 2006).*** CTCA has therefore been increasing applied to study CTO segment prior to PCI ***(Kaneda et al., 2007)***.

In CTCA axial images, multi-planar reformation (MPR) and maximum intensity projection (MIP), CTO segment completely show a lack of contrast opacification of arterial lumen) ***(Yokoyama et al., 2006)***. Contrast opacification of distal vessel, which is mostly diminutive as compared to proximal vessel, suggests well-developed collaterals in chronically occluded vessel.

Distal vessel opacification beyond totally occluded segment therefore depends on collateral filling. Lack of contrast in distal vessel is usually indicative of acute or subacute occlusion and associated with higher success during PCI. Post processing reconstructions (MPR, MIP and 3D volume rendering), help to characterize the occluded segment (both in longitudinal extent and cross-sectional images), which has a different attenuation than surrounding non-vascular tissues ***(Chartrand-Lefebvre et al., 2007; Dowe, 2007; Orakzai et al., 2006).***

AIM OF THE WORK

The aim of this study is to investigate whether multi detector computed tomography (MDCT) have an impact on the success rate of percutaneous coronary intervention (PCI) of chronic total occlusion (CTO) of right coronary artery (RCA).

Chapter 1

MULTI-DETECTOR COMPUTED TOMOGRAPHY

The introduction of MDCT CA with its rapidly growing technological developments heralded a new era in PCI. By combining the best characteristics of catheter angiography while avoiding its pitfalls, with data previously available only with intravascular ultrasound (IVUS), CTA impacted multiple facets of PCI ***(Hecht, 2008).***

Pre-PCI adequate selection of patients that have true myocardial ischemia is a major advantage of MSCT having a sensitivity of more than 90% and a specificity of 95% ***(Hecht & Roubin, 2007).*** Stress testing may be only performed after CTA to determine the functional significance of 50–75% stenoses demonstrated on CTA ***(Hecht, 2008).***

CTA, by imaging the vessel wall as well as the lumen from a 360^0 perspective, offers distinct advantages compared to CA in identification of significant lesions despite the superior temporal and spatial resolution of CA via solving many problems encountered in CA as insufficient sampling errors, overlap, foreshortening, remodeling and reference areas, minimal lumen area calculation and diffuse narrowing ***(Hecht, 2008).***

MSCT is also of extreme benefit in planning of the PCI procedure via proper stent sizing, choice of proper approach and equipment, use of 3D CTA images in the catheterization laboratory as a guide and plaque evaluation to detect calcified or high risk plaques ***(Hecht, 2008).***

Also MSCT may still have a role after invasive catheterization in cases of failed cannulation of some vessels either due to difficulty or safety issues and if additional informations (e.g.: course of anomalous arteries or grafts, assessment of LM disease especially if ostial) are required ***(Hecht, 2008).***

Diagnosis of CTO on CTCA

To diagnose a high-grade coronary artery stenosis on CTCA when reading the scans, one should look for a marked decrease in the diameter of the contrast-filled lumen, at the site of the lesion, and the site of stenosis should also show the presence of a coronary plaque. Using axial scans and oblique multiplanar reconstructions (MPRs) as the main tools on the workstation, one can estimate or measure the maximum degree of stenosis at the level of the lesion (minimal luminal diameter); compare this to a reference site, either proximal or distal to the stenosis; and get the percentage stenosis estimation ***(Hoe & Toh, 2007).*** The use of dedicated software-analysis tools may also be helpful, especially when calcifications are present.

To diagnose a CTO, one should look for complete lack of opacification of the lumen of the artery, especially in the cross-sectional views (Fig. 1). There is usually opacification of the vessel lumen distal to the site of occlusion due to retrograde collateral flow of contrast, which results in contrast opacifying the lumen, distal to the occlusion (Fig. 1). This is due to the relatively long time that has transpired between intravenous injection of contrast and the time required for the scan acquisition (*20–30 s). If there is no contrast opacification of the distal vessel beyond the occlusion, then one should suspect that the occlusion is not a chronic one but may be subacute or acute occlusion as filling of the distal vessels from retrograde collaterals is usually expected (Fig. 2). 3D-VR images are also helpful to aid in the diagnosis of a CTO as a CTO can usually be easily recognized on 3D images (Fig. 3). Note that it is also difficult to differentiate between a subtotal or severe high-grade stenosis (99%) and total (100%) stenosis on CT (Fig. 3). Both total and subtotal occlusions appear as complete interruption of contrast-enhanced lumen on CTCA. A recent study examined the parameters on CTCA that may allow differentiation between the two and concluded that this was not reliably possible due to the limited spatial resolution of CTCA. Total occlusions were found to be associated with more calcification and more marked reduction of contrast density over the lesion and tended to be [9 mm in length ***(Ropers et al., 2007).***