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Clinical Application of Cardiac CT in the Past and the Present

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Abstract

Recent developments in technology have led cardiac computed tomography (CT) to use more commonly in clinical practice over the last three decades. Compared to the invasive coronary angiogram, cardiac CT shows not only luminal stenosis but also extra-cardiac structures. This mini review of cardiac CT will help us to use it appropriately.

Keywords: Cardiac CT; EBCT; Coronary CT angiography

Introduction

Despite notable advance of diagnostic and therapeutic tools, cardiovascular disease is still the leading cause of death all over the world [1]. Over the last three decades, technical development in cardiac computed tomography (CT) has been remarkable. Even if CT provides a lot of information, however injudicious use of CT would be harm because of radiation hazard. Therefore accurate understanding and proper use of cardiac CT is very important.

Electron Beam CT (EBCT)

After the invention of the EBCT in the early 1980s, cardiac evaluation of CT was started. However EBCT showed just coronary calcium burden not coronary artery stenosis due to limitation in temporal resolution [2]. Coronary calcium score represent coronary atherosclerosis and many studies have showed it correlated to clinical prognosis [3-5]. Current guideline for use of coronary calcium score evaluation with non contrast CT defined "appropriate" in whom family history of premature coronary heart disease (CHD) with low global CHD risk and asymptomatic with intermediate global CHD risk [6].

Coronary CT angiography

In the late 1990s, multi-detector computed tomography (MDCT) was introduced, which enables to evaluate coronary anatomy after only one peripheral injection of a contrast agent with ECG synchronization. MDCT permits detection of coronary artery calcification and extra coronary artery anatomy besides coronary luminal stenosis compared to invasive coronary angiogram [7]. However heart is beating organ, which makes difficult to acquiring proper image resolution. So the patient should have regular heart rhythm with relative bradycardia (<65BPM) and also should hold the breath over 10 seconds even they had chest pain or dyspnea.

In the mid 2000s, enormous advances in medical technology enabled introduce 64-MDCT scanner and new detector materials, these improved image quality and diagnostic accuracy [8,9]. Several multicenter trials revealed diagnostic accuracy for coronary artery disease compared with invasive coronary angiography had high sensitivity (85-99%), specificity (64-90%), and negative predictive value (95-99%) [7]. Several multicenter clinical studies so far [7,10,11] supporting that the use of coronary CT angiography for low probability of disease and stable angina is effective to that of conventional stress test. In addition there are recent studies about the usefulness of coronary CT angiography to predict the prognosis and mortality [12,13].

After the 2000s with 64-MDCT, some CT protocols enable to evaluate additive clinical information besides coronary artery diseases such as Triple rule-out CT, myocardial perfusion CT, and CT angiography based computation of fractional flow reserve besides coronary CT angiography.

Triple rule-out CT (TRO-CT)

In emergency department (ED), quick diagnosis and treatment is essential for the patient with acute chest pain. This Cardiac CT protocol allows for simultaneous assessment of the thoracic organ for acute coronary syndrome (ACS), pulmonary embolism (PE), and acute aortic syndrome (AAS) [14-16]. This

protocol has higher predictive value for 30-day major adverse cardiovascular event and permits rapid triage and low admission rates irrespective of other clinical risk scores for the patient with acute chest pain in ED [17]. However, TRO-CT is associated with increased radiation exposure and contrast doses due to an extended z-axis compared with dedicated coronary CT. Therefore we should consider using this TRO-CT to patient in whom the pretest probability of ACS and PE or AAS is intermediate [18].

Myocardial perfusion CT

Although enormous technical improvement, coronary artery evaluation by coronary CT has some barriers which are heart rate, coronary artery calcification, and previous coronary stent implantation. The contrast enhanced cardiac CT can identify rest and adenosine stress myocardial perfusion defect [19,20]. Rochitte et al. [21] studied the diagnostic power of CT myocardial perfusion to identify coronary artery disease. They studied with 381 patients and showed good correlation of nuclear myocardial perfusion imaging (sensitivity of 80%, specificity of 74%, and negative predictive value 86% for the detection of luminal stenosis ≥50%). There are some limitation such as long scanning time, higher radiation dose than routine CT and lack of large randomized trial.

CT angiography based computation of fractional flow reserve (FFR-CT)

Coronary CT angiography assesses only anatomic stenosis and plaque burden not hemodynamic significance of the stenosis. FFR-CT enables to evaluate not only anatomical luminal stenos is but also hemodynamic significance by coronary stenos is [22,23].

Recently published data showed 1 year follow up of not only clinical outcome but also the quality of life and economic outcome comparable conventional invasive coronary angiogram [24]. However this methodology requires a comprehensive analysis of all arteries visible in the coronary CTA images, the analyses need to be performed centrally (Heartflow Inc., Redwood City, California) not locally [25]. Therefore current clinical data were confined to a few centers with retrospective design.

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