CURRENT & FUTURE APPLICATION OF CARDIAC CT

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Introduction

It is fairly well known, that coronary heart disease is one of the leading causes of mortality, morbidity and death in developed countries. Increasing effort has been made in screening and diagnosing coronary artery disease with different imaging modalities such as catheter angiograph, ultrasound and MRI. For long time, the electron beam CT was the only capable CT modality that was able to image the coronary arteries without any motion artifacts. Multi-slice CT has advanced rapidly in the last decade and 64-slice and dual source CT scanners are now state-of-the-art scanners for robust imaging of the coronary arteries, myocardium and valves with high quality in terms of morphology and even function.

Screening for coronary atherosclerosis and cardiovascular risk assessment

Coronary calcium screening is a surrogate marker for coronary atherosclerosis and has been measured by electron beam CT since more than a decade now. A number of prospective cohort studies are still been conducted to prove the hypothesis that the assessment of coronary calcium is superior to the assessment of conventional risk factors to estimate the risk of cardiovascular events in the future. Initial results have been published from the South Bay Heart Watch study (2,000 persons) showing that coronary calcium is of minor predictive value in patients with diabetes and that differences exist in terms of prevalence and progression of coronary calcium in different ethnic groups. The Heinz-Nixdorf RECALL study (4,200 persons) provides unbiased information about the extent of coronary calcium in the general Germany population. The authors of the Prospective Army Coronary Calcium study (2,000, 40-50 year old persons) found, that the assessment of coronary calcium by CT is superior

the conventional risk assessment by Framingham to determine the risk of future cardiac events. Similar predictive value has been found for persons with

coronary calcium and positive family history of coronary heart disease. Most likely because electron-beam CT is a rather expensive modality, the quality adjusted life year saved (QALY) was $37,633 what means that screening for coronary artery disease under these circumstance does not seem to be economically efficient. The Multi Ethnic Study for coronary Atherosclerosis (6,800 persons) recently reported, that any multi-slice CT is as least as reliable as the electron beam CT to perform and to reproduce the coronary calcium measurement4. Further studies are warranted to determine if coronary calcium screening as performed by multi-slice-CT is economically more efficient than electron-beam CT.

Coronary artery disease as detected by coronary CT angiography

Cardiac CTA has reached a robustness allowing the use of this modality in clinical routine for a variety of different clinical questions. Meanwhile more than 16 publications performed in more than 1,400 patients exist comparing 64-detector-row CT with coronary angiography for the detection of coronary artery stenoses. According to these papers, at average ninety-five percent of all coronary segments are fully accessible and comparable to cardiac catheter, demonstrating the robustness of this method. In summary the sensitivity, specificity, positive and negative predictive value of 85%, 96%, 85% and 96% has been reported, respectively. Because the high negative predictive value holds promise to reliably rule out coronary artery disease, most of the investigators focused on a cohort of patients with low likelihood of the disease. The mean was prevalence of coronary artery disease as referred to be 22%. Pitfalls for the detection of coronary artery stenoses may still occur from collateral flow, retrograde filling, plaque formation with positive vessel remodeling and extensive calcifications and grading of the degree of coronary artery stenosis remains a challenge due to limited spatial resolution in CT.

With cardiac CT, as a non-invasive method, of course no intervention may be performed. Therefore, cardiac CT may not be understood as a direct competitor to cardiac catheter, rather than a triaging tool for patients to decide for conservative or an invasive therapy. However, under these circumstances,

CTA may indeed more be seen as a direct competitor for nuclear stress test or ECG treat-mill test. In a head-to-head comparison with stress ECG, cardiac CT proved to have a significantly higher sensitivity (91% versus 73%) and specificity (83% versus 31%), respectively. In addition far less patients in this study were not assessable by CT (8%) than by stress ECG (19%).

The reliability and efficiency of cardiac CT however very much depends on the pretest probability of patient for coronary artery disease. With the given costs of approximately 630€, 175$, 130€ and 30€ for a cardiac catheter, CT, ultrasound and stress ECG, respectively, CT proves to be the most efficient modality above all others up to a pretest likelihood of 50%. In clinical terms, patients with non-anginal chest pain and women with atypical angina may benefit from cardiac CT as a rapid test for excluding coronary artery disease. Consequently, in younger male patients with atypical and younger female even with typical angina, cardiac CT may also serve as an alternative to immediate cardiac catheterization.

In practical terms, cardiac CTA may also well be suited for patients with acute chest pain. In a recently published trial, Goldstein et al reported about a cohort of patients (n=200) with acute chest pain that were randomly assigned to either the standard of care procedure with nuclear stress test or an alternative pathway including cardiac CT evaluation as the first line modality to triage patients for further workup. From their result, the authors reported that patients were worked up faster (3.4 versus 15 hours) and cheaper ($1.586 versus $1.872) with cardiac CT included than with the conventional diagnostic pathway. Furthermore, from the CT group only 2 patients returned after a certain period with recurrent chest pain in contrast to 7 patients in standard of care arm. The combination of a rapid morphological test and a functional test on demand appears to be the ideal approach in this cohort to come to a valid diagnosis.

Most recent data suggest, that CTA may also be a valid alternative in patients with coronary artery stents. However, cardiac CT lacks any information about myocardial perfusion in patients with myocardial ischemia and is therefore only of limited value when coronary symptoms are present. Furthermore, small stents are still difficult to assess and in-stent stenosis can hardly be ruled out in any case.

Assessment of coronary artery bypass grafts has gained reliability since the introduction of 64-detector-row CT. The accuracy for either arterial or venous graft is in the range of 98%. However, the distal run off or non-grafted coronary artery segments are commonly difficult to assess since the original vessels in patients with bypass grafts are commonly severely calcified.

Patients with the necessity to undergo re-operation after bypass surgery benefit from cardiac CT by the concise visualization of the grafts in particular those running behind the sternum. Cardiac CT for this purpose has clear advantage over conventional radiography and cardiac catheter. Cardiac CT also appears to be a preferable screening tool for patients undergoing cardiac surgery for non-coronary reasons.

Cardiac CT is also frequently demanded in patients with atrial fibrillation scheduled for catheter ablation. The visualization of left atrium anatomy helps to determine any accessory or anomalous courses of the pulmonary veins. CT data form the heart is used in commercially available software for planning and guiding this procedure. In this particular cohort of patients it is also important to rule out coronary artery disease to allow for anti-arrhythmic medical therapy in them.

In patients with ambiguous symptoms in the chest, it may be desirable to investigate the entire chest and to achieve a high and homogenous enhancement in the coronary arteries, the aorta and the pulmonary arteries all at the same time. For such an aim it is necessary to maintain the contrast bolus for at least the scan time and the passage time of the contrast media from the pulmonary arteries to the coronary arteries. Such a chest pain protocol may easily provide comprehensive information about the differential diagnosis of chest pain such as aortic dissection, pulmonary embolism, degenerative spine disease, esophagitis or tumor manifestation. The current drawback of this approach is the high radiation exposure the patients are exposed to for this kind of investigation.

In addition to the indications mentioned above, cardiac CT may be performed in patients with the suspicion of coronary anomalies or cardiac masses.

Conclusion

A comprehensive overview of the appropriate indications for cardiac CT is meanwhile available in the literature21. This review article lists a number of appropriate indications for CT but also considers MRI for a number of clinical questions. As a rough summery, CT is superior to display the morphology of the coronary arteries whereas MRI is superior to provide information about the function of the myocardium. Sometimes however the combination of both with allow for the most accurate diagnosis.

Therefore it is hard to believe that CT may ever serve as a one-stop-shop for any cardiac disease. More likely cardiac CT will fit into the cardiologic environment as a cost effective modality, primarily used in patients with low to moderate likelihood of coronary artery disease to quickly and efficiently decide for the appropriate therapy.

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