Indications for cardiac computed tomography

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In this article I would like to give an overview of cardiac computed tomography, present uses and its integration into everyday clinical practice.

Sir Godfrey Hounsfield (1919-2004) left behind him a huge contribution to the medical care of individuals that will only increase over the coming years. He would be greatly satisfied by the advances in computer tomography that he started in the 1970s.

We have progressed from a dedicated cranial CT scanner in 1972 (EMI scanner) that took the best part of an hour to acquire and process images to the high tech machines of today that scan a patient in seconds and produce images that would be acceptable within an anatomical textbook.

The CT technology has progressed through several generations, from a single slice rotational scanner to the now multi-slice multi-detector spiral scanner.

These advances have led to a huge advance in the spatial resolution obtained but over the recent years have also led to a marked increase in the temporal resolution (time to acquire the image). This marked improvement in temporal resolution has occurred by decreasing the gantry rotation time (less than 0.5 seconds), increasing the number of detectors and thus increasing the patient volume image per rotation. One manufacturer has also increased the temporal resolution by utilising dual radiation sources and detectors.

This marked increase in spacial and temporal resolution has allowed imaging of structures such as the heart, which show continual movement during the acquisition. It is not long ago that the heart within a CT scan of the thorax was essentially ignored, as image detail was poor due to movement blurring of the cardiac structures.

**Technique**

As in all imaging, cardiac CT protocols are devised so as to answer the clinical question and a single cardiac protocol is not appropriate. Protocol is obviously very dependent on the type of CT scanner available. Our current use of cardiac CT is outlined in table 1. The majority of examinations are performed post-contrast with or without a pre-contrast scan for calcium scoring or assessment of calcification of the pericardium. Calcium scoring is accurate, reproducible, operator independent, with high negative predictive value and adds to coronary event prediction. Attention to detail and accurate protocolling has a marked effect on the final image quality. Many centres use beta-blockers as a routine to decrease the cardiac rate, thus increasing the window for acquisition during the cardiac cycle. The systolic component of the cardiac cycle is fixed, whereas a decrease in the heart rate will result in an increase in diastole when the heart is moving least.

The timing, volume and concentration of the contrast is also important and is varied depending on the clinical question.

**Radiation dose**

Cardiac CT is recognised as a relatively high radiation dose examination. Its exact quantification is difficult, depending not only on patient habitus but also on the specific CT scanner and protocol. What is often ignored is the relatively high dose involved with conventional cardiac catheterisation and nuclear medicine imaging.

**CT coronary angiography**

CT coronary angiography has been shown to have a high negative predictive value, thus may be used to avoid invasive coronary angiography in patients being assessed for coronary artery disease, pre-surgical assessment of patients undergoing aortic valve surgery and suspected aortic course of the coronary arteries (figure 1). CT coronary angiography is being used increasingly in the assessment of patients presenting with atypical thoracic chest pain with an intermediate risk and a questionable stress test.

**Triplet rule-out**

Triplet Rule-Out refers to the fact that patients presenting with unexplained chest pain may be assessed by thoracic CT to assess the coronary arteries, to exclude thoracic dissection and to exclude pulmonary embolism. Many of the causes of acute aortic syndrome (table 4) may also be ruled out by thoracic/cardiac CT.

**Coronary artery bypass graft assessment**

Up to 30% of patients have repeat symptoms of chest pain and possible recurrent angina within one year of CABG, which may be secondary to a blocked graft or progressive atherosclerosis. CABGs are best imaged by cardiac CT (figure 3). The field of view is increased to include the lung apices down to the diaphragm. This allows a rapid outpatient assessment of CABGs, clearly demonstrating whether a graft is patent or not and also reduces the possible radiation dose to the patient that may occur at the time of catheterisation if grafts cannot be cannulated easily. In addition, this assessment allows pre-surgical planning for possible re-do operation when the position of the grafts relative to the sternum and sternotomy is required to avoid surgical trauma to any of the patent grafts.

**Pre-thoracic aortic surgical assessment**

This allows good assessment of the aortic dimensions, the extent of aortic disease and, in particular, wall calcification for the siting of grafts and for arterial clamping during surgery. It also confirms the anatomy of the aortic arch and assesses for mural thrombus.

A recent innovation is that of planning for percutaneous aortic valve repair and detailed imaging of the aortic root with appropriate measurements and full assessment of the thoracic abdominal aorta as well as the subclavian and ilio-femoral segments to confirm the best access route for the aortic device (figure 4).

**Quantification and viability imaging by CT**

Cardiac CT can be used to assess perfusion, viability and function as well as to define abnormal myocardium in acute myocardial infarction.

**Post-processing**

The availability of advanced post-processing software has lagged behind the development of the scanners themselves. As a result, post-processing can be time consuming. However, several companies now provide powerful post-processing packages that significantly simplify post-processing and reporting of these data rich scans.

**Conclusion**

Cardiac CT has come of age and is being accepted into everyday clinical practice. As the technology improves further and is available in many district general hospitals, radiology departments and radiologists have a large role to play in cardiovascular assessment and management. Radiologists must accept the challenge.

**References**


3. Coles D R, Smail M A, Nugus I S et al. Comparison of radiation doses from multislice computed tomography coronary angiography and conventional...
diagnostic angiography, J Am Coll Cardiol 2006; 47: 1840-1845.

**TABLE 1**
Current uses of cardiac CT

- Pericardial disease
- CABG assessment
- Surgical pre-assessment for CABG and other types of cardiac surgery
- Assessment of acute aortic syndrome (AAS)
- Assessment of cardiac masses
- CT coronary angiography
- Triple rule-out
- GUCH
- Pre- and post-assessment for thoracic aortic stenting and percutaneous aortic valve repair
- Assessment of prosthetic valves

**TABLE 2**
Relative contra-indications of cardiac CT

- Unco-operative patient
- Increased radiation dose – tend to avoid in young patients and those patients who are likely to undergo multiple examinations
- Atrial fibrillation/irregular rhythm/high heart rate
- Pacemakers and intracardiac devices
- Obesity

**TABLE 3**
Advantage of CT coronary angiography cf conventional coronary angiography

- Dissection
- Penetrating atherosclerotic ulcer
- Aneurysm rupture
- Intramural haematoma
- Trauma
- May be associated with Acute Coronary Syndrome (ACS)
- Spontaneous and iatrogenic

**TABLE 4**
Acute aortic syndrome

- British Society of Cardiovascular Imaging web site
  www.bsci.org.uk
- Society of Cardiovascular Computed Tomography
  www.sctc.org
- www.auntminnie.com
- Good series of articles in Clinical Radiology

**TABLE 5**
Where to learn

**FIGURE 1**
Aberrant left main stem arising from the non-coronary cusp.
FIGURE 2
Aneurysm of saphenous vein graft.

FIGURE 3
CT assessment of coronary artery bypass grafts.

FIGURE 4
CT assessment for the deployment of a percutaneous aortic.